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Volume XXXV NOVEMBER, 1953 Number 4

LINEAR PROGRAMMING APPLIED TO FEED-MIXING UNDER DIFFERENT PRICE CONDITIONS[1]

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LINEAR programming is coming to the fore in the thinking of agricultural economists. It is reasonably safe to predict that the sixth decade of this century will see this technique explored and its limitations generally understood—as the fifth decade did for production functions; the fourth, correlation analysis; the third, farm account analysis; and the second, business surveys. It is also apparent that no single individual or single group alone will explore the field.

The authors of this article foresee many papers demonstrating specific applications of linear programming. Refinements and simplifications in method will undoubtedly appear. It is our desire to contribute to this development by recording herein our present thinking regarding one application of this technique.[2] The ideas in this paper are presented in four sections: (1) The Problem Setting; (2) One Product—One Require-

[1] The authors wish to acknowledge that clerical assistance for this investigation was provided by the grain marketing project at Kansas State College.

[2] We were stimulated to examine some applications of linear programming to feed problems by the prize winning article by Frederick V. Waugh entitled, "The Minimum-Cost Dairy Feed," *This Journal*, August, 1951, pp. 299-310. He in turn credits Koopmans, Dantzig, and others as developing linear programming techniques. Readers desiring a more general and systematic presentation than Waugh's are referred to the recent publication by A. Charnes, W. W. Cooper, and A. Henderson, *An Introduction to Linear Programming*, New York, John Wiley, 1953; to the basic mathematical contribution by George B. Dantzig, "Maximization of a Linear Function of Variables Subject to Linear Inequalities," Ch. 21 in T. C. Koopmans (Editor), *Activity Analysis of Production and Allocation*, New York, John Wiley and Sons, 1951; and to applications by Clifford Hildreth and Stanley Reiter, "On the Choice of a Crop Rotation Plan," Ch. 11 in Koopmans, *ibid.*; and A. Charnes, W. W. Cooper, and B. Mellon, "Blending Aviation Gasolines—A Study in Programming Interdependent Activities in an Integrated Oil Company," *Econometrica*, April, 1952, pp. 135-159. The mixture problem is essentially the same class of problem considered by George J. Stigler, "The Cost of Subsistence," *This Journal*, May, 1945, pp. 303-314 and according to Dantzig was first formulated by Cornfield in 1941.

ment; (3) One Product–Many Requirements; and (4) Many Products–Many Requirements.

The Problem Setting

The basic problem of any firm is that of maximizing profits in the output of one or more goods, each of which may be produced by various combinations of input factors. Given a circumstance where several combinations of factors may be used in producing a given product, or where, by using other combinations of the same set of factors, a second product can be produced; and given stated product and factor prices, there is, in general, one selection of product and one combination of inputs that will maximize profit or minimize loss.[3] Under suitable assumptions linear programming techniques will point to that combination. For example, in the article already cited, Dr. Waugh demonstrated how the optimum combination can be found for the case where the firm produces one product (dairy feed) under a single given price situation.

We propose to do three things: (1) extend the application to alternative price structures and suggest for the simpler cases certain graphic devices for showing how the solution will change when prices change; (2) briefly comment on the relationship of linear programming to more conventional equal-product functions; and (3) extend Waugh's example to the case of two or more products.

To anticipate, we may note here that each of these three points implies a consideration of the extent to which inputs and outputs are substituted for each other when prices change. Moreover, the assumptions peculiar to linear programming that certain input-output relationships must be stated in linear form will be evident. This is one reason, we suspect, why more use has not been made of linear programming by economists. Most practical problems of substitution in agricultural production are not now stated in linear terms. The simple illustrations to follow indicate one method of so stating them; they also point to some basic implications of linear programming.

A complete understanding of the principles of linear programming requires some higher geometry or algebra. However, once a specific problem is set up, the mechanical techniques involved require only a small knowledge of mathematics, and a statistical clerk can easily compute solutions to problems of the type presented herein.

One Product–One Requirement

At any given time and place, the price of one feed grain is always as low or lower than any other relative to specific feeding values and within

[3] Sometimes there will be more than one solution.

limits imposed by the ability of livestock to use the different grains. This problem is one of comparing the relation between the price of two or more feed grains and the degree with which they may be substituted in livestock feeding.

For illustrative purposes we have selected the alternative of using corn or grain sorghum in a ration fed to fatten steers. The same procedure, of course, can be used to select the minimum cost ingredient for any class of livestock where dietary substitution permits and where two ingredients compete for inclusion in the ration. Examples are, wheat vs. corn, corn vs. barley, cottonseed meal vs. soybean meal, soybean meal vs. linseed meal.

According to nutritional authorities,[4] ground grain sorghum is worth from 90 to 95 percent of ground corn (on a pound for pound basis) when used to fatten beef cattle. Assuming that a pound of grain sorghum has a feeding value equal to 92 percent of corn per pound, irrespective of the proportion of the ration that is grain sorghum, the precise point of equality of cost (or indifference) can be established. Converting price per pound to bushels and hundredweights will enable a ready comparison of substitution indifference with market quotations. The relationship could be stated: $P_c = .6087P_g$ or $P_g = 1.6429P_c$, when P_c is the price per bushel of corn and P_g is the price per cwt. of grain sorghum.

With this relationship established, a price substitution chart such as Figure 1 can be prepared.[5] By using the chart, feeders can readily determine when it becomes profitable to shift from one grain to another in feeding steers. The chart allows for different feeding values per pound as well as for price quotations in different weight units (56 pounds for corn and in 100 pounds for grain sorghums). It is also assumed that a balanced ration will be fed and that the grain will be of average quality and properly prepared.

When more than two feeds are available, a series of charts similar to Figure 1 could be used to make the necessary comparisons, and through a series of "eliminations" the lowest priced grain for a given feeding value can be determined. Or the same relationships can be displayed in the form of scales, such as Figure 2. In this figure, the reading on a sorghum scale opposite to $1 on the corn scale corresponds to the slope of the line in Figure 1. This slope in turn is closely related to the slope of the conventional iso-product curve, as will be shown.

These elementary examples of linear programming specify one output and one requirement: weight-gain. Note that the nutritional relationship

[4] For example, F. B. Morrison, *Feeds and Feeding*, Ithaca, New York, Morrison Publishing Company, 21st ed., 1948, p. 524.

[5] See Leonard W. Schruben, "Should I Buy Corn or Grain Sorghum," *Kansas Farmer*, Dec. 15, 1951, for an application.

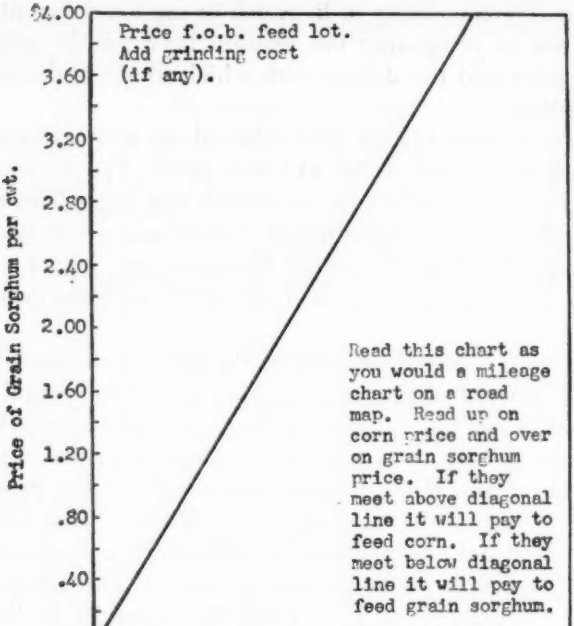
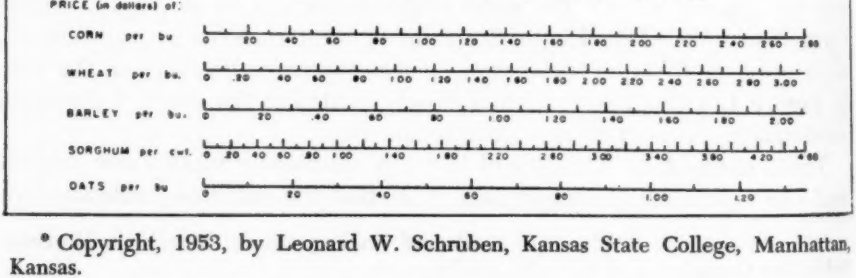


FIG. 1. SUBSTITUTION PRICE RATIO OF CORN AND GRAIN SORGHUM WHEN FED TO FATTEN STEERS.

is assumed constant throughout the range of possible substitution. Note also that the solution obtained (the grain to be used) is all of one kind; no mixture is ever needed. When the price ratio and nutritive substitution ratio are equal, an indifference is implied with respect to which grain will be used; varying combinations also may thus be used under this circumstance.



* Copyright, 1953, by Leonard W. Schruben, Kansas State College, Manhattan, Kansas.

FIG. 2. FEED GRAIN SUBSTITUTION PRICE SCALE FOR GRAIN WHEN FED TO FATTEN STEERS.

As previously stated, we have assumed in these examples that, say, a bushel of corn always supplies a certain amount of a given nutrient irrespective of the kind or quantity of other ingredients with which it may be combined. This assumption requires some modification if we wish to apply linear programming techniques to problems involving non-linear rates of substitution.

Substitution rates for two factors, X_1 and X_2, may be pictured as in Figure 3. Here the factors are perfect substitutes—one single rate holds for all possible factor combinations. Except when the price ratio is exactly the same as this rate of substitution, the product will be produced at minimum cost by using either X_1 or X_2 alone. This information may also be shown by the two zones in Figure 3b, which is a direct analogue of Figure 1.

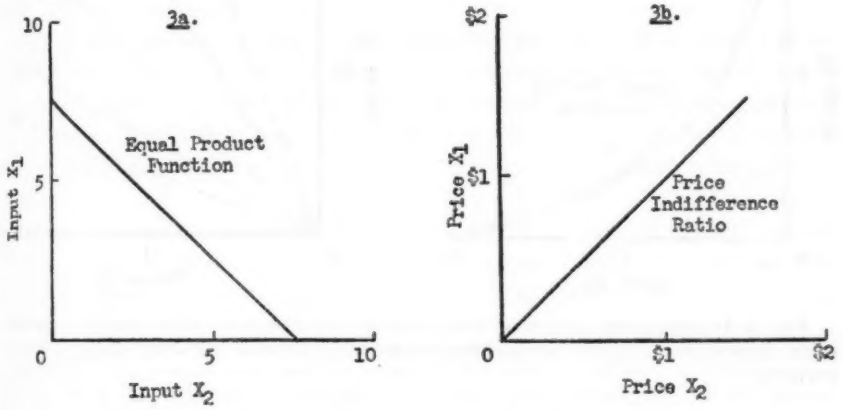


FIG. 3. SUBSTITUTION RATIO OF TWO FACTORS AND CORRESPONDING PRICE INDIFFERENCE RATIO (PERFECT SUBSTITUTES).

In the case where physical substitution is at a continually diminishing rate, the minimum-cost feed for any price situation may be found to any desired degree of accuracy by a linear programming approximation. To illustrate, consider the continuous convex equal-product function in Figure 4a and also Figure 4b, having the appearance of a fan. Conventional exposition shows that for any price ratio of the two factors a slope can be drawn in Figure 4a representing the quantity-exchange ratio, and the point where the equal-product curve has this slope represents the solution. Moreover, the price ratio itself can be plotted as a ray in Figure 4b. Thus, for any possible ray in Figure 4b there corresponds a solution representing a particular combination of X_1 and X_2 and shown by a point in Figure 4a. (For ray A or ray B the solution is point A or B respectively; if units of measurement and scales are the same in each diagram, and if one diagram were to be superimposed on the

other, the slope of any ray would be perpendicular to the slope of the tangent to the corresponding solution point.)

Now let the iso-product curve be approximated by three linear functions shown as dotted lines in Figure 4a. Then four zones may be set up in Figure 4b (bounded by the dotted rays) showing that for any given price ratio the solution will be either all X_1, combination B, combination A, or all X_2. Once these zones are obtained and labelled, it would not be necessary to refer back to Figure 4a; the minimum-cost combination could be read directly off Figure 4b. A set of scales, such as Figure 2,

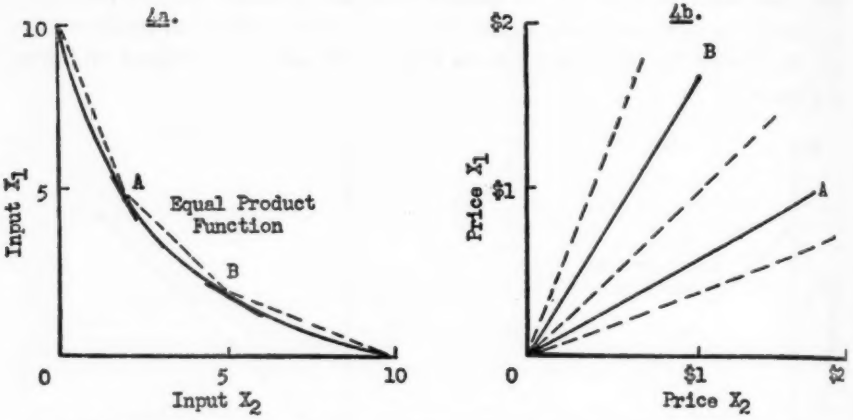


FIG. 4. SUBSTITUTION RATIOS OF TWO FACTORS AND CORRESPONDING PRICE INDIFFERENCE RATIOS (CONTINUOUS DIMINISHING RATE WITH LINEAR PROGRAMMING APPROXIMATION).

could also be devised to show the solutions. These solutions are exact for the segmented iso-product curve, but only approximate for the original curve.

More accurate approximations may be obtained from the linear programming approach by using more linear functions. In fact, as many could be used as the desired degree of accuracy demanded. In some problems a finite number of linear relationships is more realistic than a continuous non-linear one; in such a case linear programming would give the true solution.[6]

One Product—Many Requirements

What has been presented heretofore represents only the most simple relationships of resource combination. Where a choice lies between two factors the devices above are helpful. When more complicated choices

[6] For a more general statement of the relationship of linear programming to conventional production functions, see Koopmans, *op. cit.*, pp. 5-6.

are examined, other methods may be used. This and the subsequent section deal with two such situations.

In many states the chemical analysis of the contents of each bag of commercially mixed feed is given, along with the ingredients, on a tag attached to the bag. Once a tag has been affixed to a bag of feed, the manufacturer is required by law in many states to meet the stated specifications. These are usually stated in percentage form (e.g. 24% protein), and typically several such requirements have to be met at the same time. The manufacturer of livestock feed has the problem of preparing a mixture having all the specified chemical requirements at a maximum profit. One of the items he must account for is ingredient cost. Other considerations should be taken into account such as labor, overhead, and buyers' acceptance of a product with changed appearance, but these problems will not be examined here.

As in the previous problem, the manufacturer has a wide variety of ingredients to choose from. Each has unique chemical characteristics. These chemical characteristics of ingredients remain unchanged by inclusion in a physical mixture. Ingredient prices, however, may change over time in absolute level, in relation to each other, and in relation to product prices.

This problem is basically the same as that of the preceding section, except that we have now several requirements instead of just one. Dr. Waugh's solution can be applied directly.[7] The problem as formulated by

[7] Waugh, *op. cit.*, pp. 301-309. In applying Waugh's solution to the problem being considered here, some care must be taken to formulate a capacity requirement correctly. With the criterion of maximum profit, and with a selling price of the product high enough to cover variable costs, it would pay to expand production indefinitely unless some capacity limitation were imposed. (If selling prices were not high enough to cover variable costs, it would pay to shut down completely.) If a fixed rate of output is assumed, then maximum profit and minimum total cost become equivalent criteria. (Without any such assumption the criterion of minimum total cost would always give a solution of zero production.)

In the latter two of his "four sets of requirements" (p. 301, par. 4) Waugh assumes a fixed rate of production of 100 lbs. In the former two, Waugh does not state capacity or rate of output assumptions. In our opinion he arrives at his solutions in these two cases (given on p. 306 and 309) only by stating his nutritive requirements in pounds (Table 1B), rather than in percentages. Since the original requirements are in percentages, such statements in absolute pounds can have meaning only if an output requirement of 100 pounds is intended. But these two solutions are *not* the correct ones either for an upper-bound restriction of 100 pounds or an exact restriction of 100 pounds (e.g. the solution on p. 306 weighs only 96.9 pounds). In our opinion they would be correct only under the assumption (not stated by Waugh) that a costless filler having no nutritive content is available to fill up the 100 lb. sack.

In our examples of the next section, we shall postulate all chemical requirements in percentages, and assume a maximum output of 40,000 lbs. per day (400 sacks of 100 lbs. each). The conventional pricing unit of 100 pounds could have been used, but this unit of course does not indicate scale of plant, nor the possibility of purchase

Dr. Waugh, however, differs from ours in one important way. Of his requirements, two are "total digestible nutrients" and "digestible protein" and we may doubt whether such variables can in reality be regarded as a constant proportion of an ingredient when different ingredients are mixed together in varying proportions. Linear programming requires such an assumption, or suitable modifications of it.[8] We have preferred to state all requirements as chemical specifications, since chemical properties of ingredients can be regarded as constant for all possible mixtures.

It should also be stated that when the number of requirements and ingredients becomes large, the solution will not be obtained so easily as indicated in Waugh's article.[9]

When ingredient prices change, the solution must be reworked. In the rather simple case when only two prices change and all other prices remain constant, it is possible to demonstrate graphically all possible solutions that would arise. Figure 5 shows all possible solutions that would be obtained in Waugh's first two-requirement problem[10] on the assumption that the prices of gluten and of milo are variable, and the prices of all six other ingredients are fixed at the values stated by Waugh. This problem is to find the minimum-cost feed that will provide 74.2 lbs. of total digestible nutrients and 19.9 lbs. of digestible protein. In the figure six zones appear, each zone representing a possible solution. Waugh's solution (when milo is at \$2.18, gluten at \$2.60) is shown as a dot. It is a feed consisting of 83 lbs. gluten and 14 lbs. flour middlings. But it won't require much of a price change to make a different mixture most profitable, as can be seen from the figure.[11]

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and sale in bulk. If we were to state the problem with a 100 pound restriction, and if all percentage requirements were held constant, the ingredient solutions would all be 1/400 of our solutions presented in Table 2 *infra*.

We also presume that the last formula on p. 301 is a misprint, and should read: $Y_{ij} = X_{ij}/p_i r_j$.

[8] Waugh specifies that the requirements may not be correctly stated by Morrison. He leaves the reader with the notion that nutritive values of ingredients do not change when varying proportions of ingredients are used in a mixture. We are concerned with the relative nutritive values of an ingredient when used in several alternative combinations to illustrate further the limiting conditions to an application of linear programming techniques. While "the amounts of nutrients in the feed mixture are linear functions of the quantities of corn, oats, bran, and other feeds," (*Ibid.*, p. 300) the nutritive values do not necessarily have this relationship. It should be recognized that our own formulation in terms of chemical requirements suffers from the same limitation in that they do not necessarily reflect nutritive values. In short, nutritive values may be different than chemical composition.

[9] In footnote 9 (*Ibid.*, p. 308) the selection of certain feeds in the solution is verified, but in the selection, intuition and hunch play a large part. In some problems, including Waugh's, such a procedure will be the most desirable, but not in all.

[10] *Ibid.*, pp. 303-306.

[11] The idea for Figure 5 came from a somewhat similar figure in Hildreth and

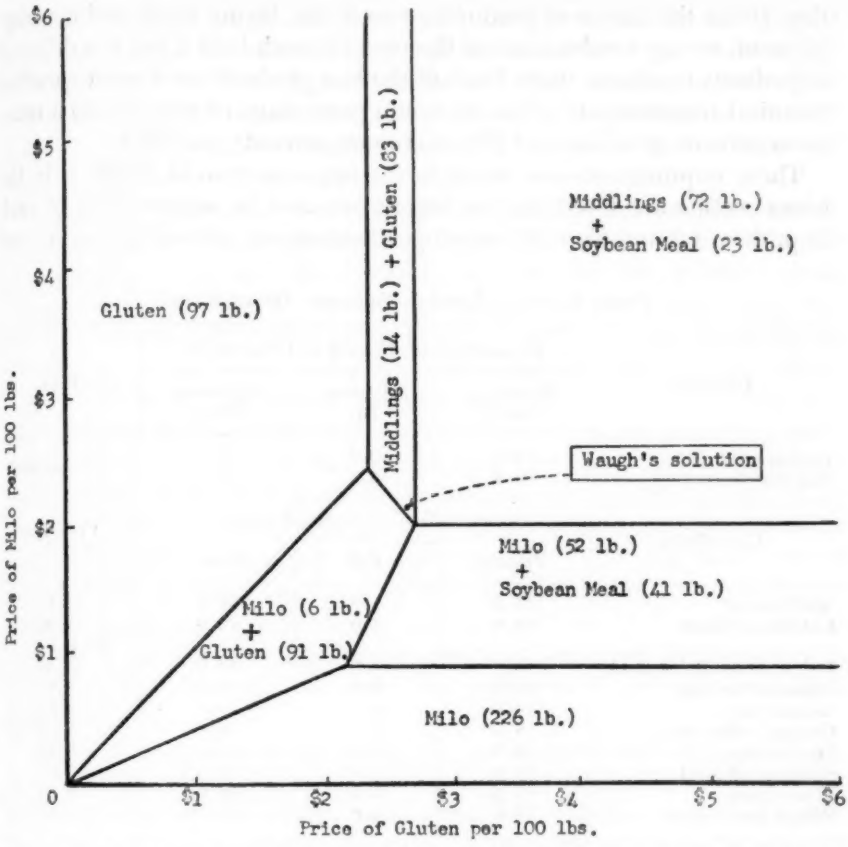

FIG. 5. THE MINIMUM-COST FEED MEETING TWO REQUIREMENTS WHEN TWO PRICES VARY—OTHER PRICES CONSTANT.

Many Products—Many Requirements

Of more general interest than the problems heretofore discussed are those when the firm has the choice of alternative products as well as of alternative ingredients. Linear programming techniques can be applied to problems having any number of products or requirements, although the computations may take longer.

To illustrate, we shall consider a two-product problem. Our firm has a capacity permitting it to handle a maximum output of 400 hundredweight (e.g. 400 sacks of 100 lbs. each or 200 sacks of 200 lbs. each) per

Reiter, *op. cit.*, Ch. 11, where a different problem was considered. In Figure 5 the solution zone indicating 226 pounds of milo (for very low milo prices) is another illustration of the difficulty mentioned in footnote 7 above, where absolute requirements rather than percentage requirements are specified. In practice, such a solution would not be adopted. It is shown only to allow the reader to make comparisons with Waugh's solution.

day. It has the choice of producing two feeds: laying mash and hog supplement, or any combination of the two; for each feed it has ten different ingredients to choose from. Each of the two products must meet specified chemical requirements: (1) a minimum percentage of protein; (2) a minimum percentage of fat; and (3) a maximum percentage of fiber.

These requirements are stated in the upper section of Table 1; in the lower section are listed the ten ingredients and the composition of each in protein, fat and fiber. These proportions are not altered by mixing and

TABLE 1. A TWO PRODUCT PROBLEM—GIVEN DATA[a]

Products	Requirements—Percent of total weight			Price
	Minimum Protein	Minimum Fat	Maximum Fiber	
Laying mash (L)	18.0	3.0	8.5	Not specified
Hog supplement (H)	28.0	3.0	10.0	
Ingredients	**Composition—Percent of weight**			**Price per 100 lbs.**
	Protein	**Fat**	**Fiber**	
Alfalfa meal	15.0	1.0	30.0	$2.80
Cottonseed meal	41.0	4.0	13.0	A—7.00 B—3.50
Dehydrated alfalfa meal	15.0	1.0	30.0	3.40
Digester tankage	60.0	6.0	3.0	5.80
Ground oats	11.0	4.0	11.0	3.65
Ground yellow corn	8.5	3.8	2.0	4.37
Meat scrap	55.0	9.0	3.0	6.48
Soybean oil meal	41.0	4.0	6.0	5.85
Wheat bran	14.5	3.5	10.0	3.74
Wheat grey shorts	16.0	4.0	6.0	3.96

Daily capacity of plant assumed: 400 sacks

[a] Source of data: Purdue University Agricultural Experiment Station, Circular 384 and the *Kansas City Grain Market Review*.

therefore the amounts of protein, fat, and fiber in the final product is each a linear function of the quantity of each ingredient included.

We want to know what will be the daily production program to be scheduled by this firm in order to make a maximum profit—that is, how much of each product it will produce, and how much of each ingredient it will assign to each product. We also want to know how this decision will be altered when market prices change.

Let us first consider the problem for a given set of prices. Assume that ingredient prices are those listed in the last column of Table 1. (We shall consider that the price of cottonseed meal is first $7.00 and then $3.50.) Assume that the prices obtainable for the finished products, hog supplement and laying mash, are also known; we shall not specify them in

dollars and cents, but denote them by P_H and P_L respectively. A net profit function may be constructed that is linear in terms of quantities of ingredients assigned to each product (20 variables). Requirements may be specified as seven inequalities (three chemical requirements for each product and one capacity requirement). The simplex method of Dantzig[12] may be applied directly to obtain a solution.

The same solution may be arrived at by the following line of reasoning. If the enterprise had the choice of only *one* of the two products (Waugh's problem), it could find the optimum program for this product alone. Moreover, it could do so for each of the two products separately—say, for L and for H. With given prices P_L and P_H each of these two programs will give a certain profit, and of these two programs the one that will be chosen will be the one that gives the higher profit of the two.[13] This program will be the same solution as that mentioned in the preceding paragraph. Moreover, we see that it will never be necessary to consider a combination of the two products. Either one or the other alone will be more profitable, and the full capacity of 400 hundredweight should be used to produce the one that is more profitable.[14] Thus, we have reduced the problem of many products to that of choosing among solutions of smaller problems, each specifying only one product. (A somewhat similar procedure for the less complicated case was suggested by Figure 1.) It will often be convenient to make this reduction in actually computing the solution.

This way of looking at the matter has merit also in indicating what happens when product prices change and ingredient prices remain constant. Say we have computed the profit from the optimum hog supplement program (H) and from the optimum laying mash program (L) and that H is found to be more profitable. We can also compute the profitability per 100 lbs. of product for each program, and also the difference in profitability, say $z_H - z_L$. Then we see that if prices P_H and P_L change in such a manner that the difference $P_H - P_L$ is *decreased* (prices changing in favor of L) by *more* than the profit difference $z_H - z_L$, it will pay to change over and adopt the L program. Otherwise, although prices and profits may change, it will pay to continue with the H program. We can, moreover, compute a critical price difference for which the profit difference $z_H - z_L$ is zero (same profit for each program). Then we know that the program that will be adopted will depend on whether the actual difference in market prices is less than or greater than this critical dif-

[12] See Dantzig, *op. cit.*

[13] In a borderline case of equal profit it is indifferent which program will be selected. (Here we assume that prices are such that both profits will be positive.)

[14] In the borderline case, it is indifferent whether the capacity be used for all one, all the other, or any combination of the two.

ference, which we may call d^*, regardless of the absolute level of prices. (Of course, we assume all costs to remain constant. See introduction.)

The practical value of the above comments is limited by the fact that the critical product price difference d^* will, in general, be different for each possible set of ingredient prices, and that ingredient prices are, in reality, changing just as frequently as are product prices. Consequently, it will usually be necessary to recompute solutions for simultaneous changes in several different prices.

Four possible solutions to the specific problem stated above are presented in Table 2.[15] When the price of the ingredient cottonseed meal is

TABLE 2. SOLUTIONS FOR THE TWO-PRODUCT PROBLEM UNDER FOUR DIFFERENT PRICE SITUATIONS

			When price of cottonseed meal is:			
			A. $7.00 per cwt.		B. $3.50 per cwt.	
			Critical difference in product prices d^*, $(P_H - P_L)^*$, is:			
			$.326 per cwt.		−$.108 per cwt.	
Maximum profit solution (all figures in cwt.) is:						
When difference in product prices, $P_H - P_L$, is:	1. *Greater* than the critical difference d^*	Product	hog supplement	400.0	hog supplement	400.0
		Ingredients	alfalfa meal digester tankage wheat grey shorts	80.5 110.9 208.6	cottonseed meal wheat grey shorts	228.6 171.4
		Over fulfilled requirements	fat	3.8	protein fat	9.2 4.0
	2. *Less* than the critical difference d^*	Product	laying mash	400.0	laying mash	400.0
		Ingredients	alfalfa meal digester tankage wheat grey shorts	44.1 19.2 336.7	cottonseed meal ground oats wheat grey shorts	56.3 121.3 222.4
		Over fulfilled requirements	fat	3.1	fat	4.0

at $7.00 per cwt., (other ingredient prices as listed in Table 1), it is found that the critical difference in product prices that gives equal profit is $d^* = 32.6¢$ per cwt. When the difference in market prices $P_H - P_L$ is more favorable to H than this figure, hog supplement will be produced, using quantities of ingredients indicated in section A1 of the table. If difference in market prices is more favorable to L than this figure, laying mash will be produced, using ingredients indicated in section A2. If the price of cottonseed meal falls to $3.50, it is found that the critical price difference becomes $d^* = -10.8¢$ per cwt. The two optimum pro-

[15] The solutions were computed by the simplex method, making use of the format recommended by Charnes, Cooper, and Henderson, *op. cit.*, p. 10; an earlier version of this format in hectographed form was kindly made available to the present writers. The computations were carried out by Mr. Joe Unger, student assistant in the Department of Economics and Sociology, Kansas State College.

grams in this case are presented in sections B1 and B2 of Table 2.

It should be noted that all of these solutions involve exact full use of the maximum capactiy of 400 cwt., and at least one of the chemical requirements is overfulfilled. The requirements that are not shown as being overfulfilled in Table 2 are, in each case, fulfilled exactly.[16]

It would be possible to construct a chart similar to Figure 5 for this problem, taking either two ingredient prices as variables, or one ingredient price and the difference in product prices—all other prices assumed constant. However the amount of computation necessary for the chart would be greater in this case, because of the greater number of requirements in the problem. For problems having many requirements, and for realistic cases when several prices vary together, other devices for obtaining the solution in a reasonably short period of time will probably have to be developed.

[16] It would, of course, be possible to obtain fulfillment of all requirements by using four different ingredients, but such a solution would not be that of maximum profit. It is *not* assumed here that a costless filler is available. If it were, the solutions would be different; requirements could be met at higher profit by exact fulfillment with less than 400 cwt. of the nutritive ingredients (cf. Waugh's first two problems discussed in footnote 7), using the filler for the balance.

ECONOMICS IN AGRICULTURAL COLLEGE CURRICULA

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THIS article reports the results of further inquiry and analysis of the questions raised in the article in this JOURNAL of August 1952 under the title "Required Economics for Agricultural Students." Copies of that article were sent to all heads of departments of agricultural economics and deans of instruction in land-grant colleges of agriculture,[1] with a request that they indicate their reactions to it. Replies have been received from most of the colleges. Also further study has been made of the annual catalogues of these colleges and uncertain points have been cleared by correspondence. The analysis will be broader than that in the first article and will consider the economics in curricula as wholes rather than in just the required parts of these curricula.

Let it be understood from the outset that this article will state few conclusions as to policy and make few if any recommendations. Its purpose instead is to present the different alternatives and the advantages and limitations of each, so that those who have decisions to make in this field will make them more understandingly.

There is no more outstanding fact revealed by this study than that the alternatives are many and varied. There will presently be listed no less than 21 different arrangements for only the beginning two or three courses in economics, ranging all the way from virtually no required economics in two colleges to nine semester credits of economics in another two. It is to be doubted if need for economics training differs much among the states. Special circumstances and historical background in each college must largely account for this wide assortment of arrangements.

After each description in the following classification will be given two numbers, the first being the number of colleges having this arrangement, and the second the percentage of all agricultural students (4-year course undergraduates) in agricultural colleges of this country who are in the colleges having this arrangement. The number of agricultural students includes in eight cases the men in forestry departments or divisions of these colleges.

Later a third measure is introduced, namely, the number per 100 undergraduates in these colleges that are majoring in agricultural economics. This measure was conceived originally as an indication of how well the courses are being received by the students. It serves this purpose only very loosely. In some of the colleges, the set of courses, or curriculum, for a major in agricultural economics is designed primarily to train men even in four years to be specialized enough to undertake jobs in teaching,

[1] The Negro land-grant colleges will be covered in a later inquiry.

research, and administration in this field. In others, the curriculum in agricultural economics is little more than the curriculum in "general agriculture" offered in many other colleges. Also concentration in part of the colleges begins in the second year, and in a few even in the first year. Following are the totals for 48 agricultural colleges:

Agricultural students in 48 colleges	31,660
Agricultural students in 39 colleges reporting majors in agricultural economics	26,913
Total majors in agricultural economics in the 39 colleges	1,631
Average majors per 100 students	6.0

The average number per 100 for the 39 colleges which reported departmental majors in agricultural economics therefore was 6.0.[2] If it were assumed that only 45 per cent of the students are in the two upper classes, as in a group of the colleges in a recent year, and that concentration begins in all of them in the third year, this 6.0 would become 13.5 per 100 in the two upper classes. The 13.5 would become only 8.6 in the three upper classes if concentration began in all of them in the sophomore year. The correct figure is probably around 11. This would mean that about a ninth of the undergraduate men in our agricultural colleges are majoring in the economics of agriculture.

In comparing the extent of concentration in the different colleges, however, the number of concentrators per 100 students would be highest, other things being the same, in the colleges where concentration begins in the first year, because the concentrators are counted in all four classes, and lowest in the colleges where concentration begins in the junior year.

The following classification must not be taken as highly accurate. If fuller information were available, a few of the colleges would be put in other classes:

The More Usual Arrangements

A. All or nearly all agricultural students required to take the general course in principles of economics given in the university or college, with no required course in agricultural economics afterwards—13 colleges, 28 per cent of all agricultural students.

This group of 13 colleges can be further subdivided as follows:

3 Semester credits	5 colleges	11.0 per cent of students
4 Semester credits	1 college	1.3 per cent of students
5 Semester credits	1 college	4.7 per cent of students
3 or 6 Semester credits	1 college	1.6 per cent of students
6 Semester credits	3 colleges	6.7 per cent of students
3 Quarter credits	1 college	1.9 per cent of students
5 Quarter credits	1 college	1.3 per cent of students

[2] Those with no majors in agricultural economics have curricula like "General agriculture," with ordinarily around 5 or 6 courses in agricultural economics in them, or majors in "economics" with possible specialization in the economics of agriculture. In figuring majors per 100 students for the groups following, the colleges with no majors reported are omitted.

The basic idea of this arrangement is that the students will be given an understanding of the elementary principles of economics in such a general course, just as they do of chemistry and biology in their basic courses in these subjects, and that they will get the applications of these principles in junior and senior courses in agriculture. The particular advantage of this arrangement from the standpoint of general university or college administration is the saving in teaching cost from having the agriculture students sit in on the same big lectures as the arts college students and fit into the same section meetings. It is also pointed out that these big courses are likely to be well organized and to have effective lecturers. It is also argued that college students need the contacts with liberal arts students that they get from participating in the same courses with them.

The letters which I have received from deans of agricultural colleges and some department heads strongly indicate, however, that this arrangement is not working well in part of the thirteen colleges. Part of these complaints add up to the statement that not enough applications of the principles are made to things the boys know about so that they have much meaning for them. Some of them say that the liberal arts teachers of economics apparently do not know enough chemistry and biology to tie the principles of economics in with the natural science the boys are getting, or are about to get, in the agricultural college. It will be obvious that the principles of economics that students of agriculture need most are those of production economics, and these receive scant attention in most textbooks on the principles of economics. Closely related to this, the attention in the general arts college courses in principles is about all centered upon political economy or macro-economics, and very little upon the economics of the individual operating unit or micro-economics.[3]

In several of the colleges in which 5 or 6 or more semester credits in general arts college economics are required, a further criticism is strongly advanced, namely, that such courses refine and elaborate the principles of economics well beyond what is needed for the agricultural student who is not going to major in economics, and particularly along lines that are not very pertinent for agriculture. They also point out that the arts college course in principles is likely to be elective for its students, and ask why such a course should be required of all agricultural students.

B. Like A, except that the course in principles is given in the department of agricultural economics, and presumably adapted more or less to the interests and needs of students of agriculture—3 colleges, 11 per cent of students.

[3] "We have been dissatisfied with results in teaching the five-hour course in principles in Arts and Sciences. It is our conclusion that students have very little appreciation of the relation of economics to their activities after they finish college."

The courses in principles of economics in these three colleges carry 6 or 9 semester credits, 8 quarter credits, and 6 quarter credits respectively. Much less criticism of these than of the foregoing appeared in the correspondence. Clearly it is more feasible to give special courses in general economics than in general chemistry or biology in the College of Agriculture since no costly laboratories need to be duplicated.

C. Courses required in both general principles of economics and in general agricultural economics—8 colleges; 12 per cent of students.

This is thus second in frequency of the arrangements, but not a close second. The general principles course is for 3 or 4 semester or quarter credits, and the agricultural economics course for 3 semester or 3 quarter credits. This arrangement is obviously designed to insure that all agricultural students have a chance to learn the body of principles of economics that are important for agriculture and see how they are applied. Some of the letters received stated that with limited space available in the curriculum it was more important for students of agriculture to get this body of principles and application than more refinement of the general principles.

D. Choice of A or C; that is, either 6 semester credits of general principles, or 3 of these plus 3 of general agricultural economics—2 colleges, 2 per cent of students.

In practice this means that students majoring in certain fields generally take, or may be required to take, the 6 credits of general economics, and those majoring in other fields the split arrangement. Also many students choose to take both. This arrangement has the advantage of flexibility to fit the needs of students.

E. Either general economics, *or* general agricultural economics, required, but not both—3 colleges, 7 per cent of students.

The courses offered to fit this arrangement are all 3 semester-credit courses. In this case too, the choice is governed considerably by the major field elected.

F. Only general economics of agriculture required—4 colleges, 5 per cent of students.

The courses offered range from 3 quarter credits to 3 semester or 5 quarter credits.

Special Arrangements

The foregoing six arrangements cover 33 of the 48 colleges, 64 per cent of the students. The concentration ratios for these average 6.3 majors per 100 students. The remaining 16 colleges each have an arrangement peculiar to it, although in some cases the resemblance is close to one of the foregoing A to F.

First will be listed the three institutions which have a two-year basic

curriculum required of all students. The economic components of these curricula differ greatly.

G. The basic course includes 9 semester credits in "American Institutions," and no required agricultural economics. The 9-credit course contains relatively little of economic principles.

H. The basic 2-year curriculum includes 9 quarter credits of Basic Social Science, a third of which is general principles of economics, and a 9 quarter-credit course called "Effective Living" which includes a good bit of consumption economics. In addition most of the students are required to take 3 quarter credits of Production Economics and one course in the economics of agriculture.

I. Fifteen semester credits in Social Science, which must include 3 semester credits of general economic principles.

The summary figures for G, H, and I are: 3 colleges, 6 per cent of students.

Second will be listed 4 institutions in which all of the students take a required course in general economic principles, but all or most of them take a preparatory course of some kind. The reason advanced for this is that the students find the general economic principles course rather abstract and meaningless, and are unable to relate the principles to agriculture without such a pre-induction course.

J. A 5 quarter-credit course in "Economic Trends" followed by 5 quarter-credits of general economic principles. The first course presents some of the elementary principles of economics in their applications to agriculture. No other agricultural economics is required.[4]

K. A required preparatory course in Agricultural Geography (3 semester) plus 9 semester credits of other general social science, which for most students includes general principles of economics.

L. 9 quarter credits in general economic principles, preceded in most cases by a 3 quarter-credit course in agricultural economics.

[4] "The reason for making this change was that we found many of the agriculture students were rather concrete thinkers and had difficulty in associating the principles which they dealt with in the General Economics course with the actual problems of life. The thought was that our new course in 'Economic Trends in Agriculture' would be a little more concrete and acquaint the students first with some of the developments that are going on of economic significance and thus give them a better background for the course in principles. Another reason for making this change was that under the old arrangement students could not take their course in Economics until their sophomore year which made them juniors before they had the first course in Agricultural Economics which was a prerequisite to all other courses in Agricultural Economics. This meant that our course in Agricultural Economics was taken mostly by juniors and seniors. Under the new arrangement the course in Economic Trends in Agriculture is taken largely by sophomores and some freshmen. We like this new arrangement better than the old since it introduces the student earlier into the field of Agricultural Economics and starts him off with a little more concrete approach."

M. 6 semester credits of general economic principles, ordinarily preceded by a 3-credit course in agricultural economics, and followed by one required semester course offered by the department of agricultural economics.

The summary figures for J to M are: 4 colleges, 14 per cent of students.

Third are four institutions which *require* no economics of any kind of all students, but in which most of them do take at least one economics course.

N. Required 6 semester credits chosen from general economics, agricultural economics, or sociology.

O. About 80 per cent of the students take a 3 semester-credit course in the economics of agriculture.

P. No economics of any kind required except what is included in a required 3-quarter course in Agricultural Geography.

Q. Only the more important curricula require economics, and these require 4 semester credits of general principles plus 4 of general agricultural economics.

The summary figures for N to Q are: 4 colleges, 9 per cent of students.

R. A required 3 semester-credit course in economics with application to agriculture.

S. Like R, plus 3 semester-credits each of marketing and of farm management required of all.

T. Required 3 semester credits each of general economics, agricultural economics and farm management.

U. Required 9 quarter-credits of farm management plus 3 quarter credits of agricultural economics.

The summary figures for this miscellaneous group are: 4 colleges, 6 per cent of students.

Résumé

It will be obvious to the reader that summarizing the foregoing or generalizing from it is difficult and hazardous, but a little of this will be attempted. First, it can be said that there is a group of seven colleges with 24 per cent of the enrollment in agriculture that requires a rather *heavy dose* of general principles—or the equivalent—and no economics of agriculture. If we exclude one of these seven in which the agricultural economics major is essentially a general curriculum in agriculture, the concentration ratios average only 4.3, but the range is from 2.5 to 7.8. In these colleges, however, the course in economics is commonly taken in the sophomore year, which means that concentration may not begin before the junior year, which will tend to lower the concentration ratio. Still, it is possible that many of the students consider that they have had enough

of economics after 6 semester credits of general principles. More serious questions are whether, first, those who take no more economics really integrate what they have learned in the general course with their agricultural science, and secondly, whether those who later take even two or three courses in the department of agricultural economics cover enough of the different aspects of the economics of agriculture.

A second group of eight colleges require only 3 semester or quarter credits of general principles and no agricultural economics, and the concentration ratios for these average only 4.6, if one college with a general-agriculture type of curriculum in agricultural economics is omitted. The range is from 2.7 to 6.7. It could be, however, that the students in these colleges elect more courses in farm management, marketing, etc., than those in the first group.

The group of ten colleges requiring 3 semester or quarter credits of both general principles and general agricultural economics are mostly small colleges. They represent only 15 per cent of the enrollment. But the concentration ratios in these average 6.5, ranging from 2.0 to 7.4. For the group of seven colleges requiring 3 credits of one or the other, or of only agricultural economics, and with 12 per cent of the enrollment, the concentration ratios average 6.9, with a range from 3.3 to 9.1.

The low average concentration ratio of 4.3 for the colleges with a 2-year basic general education course is partly due, of course, to the fact that in these colleges the concentration can really begin only in the junior year.

Surely significant is the high concentration ratio average of 9.5 for the four colleges that start their students off with a preparatory course in agricultural economics or geography.

Still higher are the majors ratios—from 13.0 to 18.0—for departments of agricultural economics with a curriculum of the general-agriculture type, including ordinarily the equivalent of 5 or 6 semester courses in economics. Such curricula, however, are commonly elected in the sophomore year.

Finally pertinent is the circumstance that the lowest majors ratios of all tend to be in the colleges in the miscellaneous group and in those requiring no economics at all. The obvious implication of this is simply that economics has not yet obtained much of a foothold in these colleges, but for two of them at least a more accurate statement would be that the departments of agricultural economics have preferred to concentrate on making good economists out of a smaller group of students. The majors in economics get plenty of economics.

The Curriculum in Agricultural Economics

The foregoing review brings to the fore some fundamental issues as

to the objectives of agricultural college curricula in agricultural economics. Such curricula can on the one hand be focussed preponderantly on giving the rank and file of the students in the college the body of economic knowledge and principles that they need as future farmers, businessmen dealing with farmers or handling farm products, and as teachers of agriculture, extension workers, and other public servants of agriculture. They can on the other hand be focussed on turning out specialists in agricultural economics. Or they can combine these two objectives. The choice should be influenced strongly by the particular characters of the institution. A small college separated from a general university is most likely to choose the first focus, a large college in a big university more likely the second. This writer pleads guilty to a prejudice on this subject. He sees no reason why these latter colleges cannot serve both purposes, and considers them derelict in their duty to their states if they do not organize their instruction in economics in such a way to give the rank and file of the students something like the body of economics outlined in his previous article on "Required Economics for Agriculture Students," and in addition offer follow-up courses in farm management, marketing, prices, land economics, and credit that will attract a goodly number of general-agriculture students and majors in such fields as animal, dairy and poultry husbandry, agronomy, and horticulture. Of these courses, the farm management is the most important, and all majors in these production departments and in general agriculture should have a course in this field which is at the same level of intellectual advance as the courses in Soils and in Feeds and Feeding, and it should follow these courses. The elementary courses in farm record-keeping and the like now commonly offered do not suffice for this need.

Review of the catalogues of the agricultural colleges suggests that departments of agricultural economics in the larger colleges at least should consider offering three curricula, one of the general-agriculture type to serve especially the needs of future farmers and extension workers, one in agricultural business to serve the needs of young men looking forward to a career in businesses serving farmers, and one to prepare agricultural economic specialists. The follow-up courses in the first curriculum should ordinarily all be obtained in the college of agriculture; in the second, partly in the undergraduate schools of business in the university; and in the third, partly in the departments of economics in the university.

Possibly qualifying the foregoing somewhat is the circumstance that more and more of those majoring in other fields and feeling the need for more economics are staying on for a fifth year and taking a master's degree; and that this is even more true of those specializing in agricultural economics.

The smaller colleges can prepare economic specialists through the B.S. stage if they utilize some of the follow-up courses in general economics offered in the college, and through the M.S. stage if they can in addition find useful research projects upon which to give the students part-time experience over a two-year period. But their major responsibility is to give the rank and file of the students a working body of economic facts and principles.

The other important question needing further analysis is whether or not a course in general agricultural economics should be offered. Exactly 36 of the colleges do offer such a course, 15 of them as a required course for all or nearly all students, and 21 as an elective for majors in other fields and almost always required of majors in agricultural economics. Of the remaining 12 colleges, 2 require a 3 semester-credit course in "economics with application to agriculture," 1 requires 5 quarter credits of "Economic Trends" and 2 offer elective courses in "Production Economics." In these 12, the students taking additional economics go directly from a general principles course to courses in farm management, marketing and the like. Furthermore, the elective course in general agricultural economics is by no means always a prerequisite for the courses in farm management and marketing, and may instead be in effect an alternative to them. Surely to make it both an alternative and a prerequisite in the same college offers difficulties. The reader should also be reminded that in 5 of the 21 colleges with an elective course in general agricultural economics, this is an alternative to part or all of a course in the general principles of economics.

How Much Economics

To deal more specifically with the reactions to the previous article, it can be said that no one took exception to its views in favor of more economics for agricultural students, but several felt that the article covered too wide a range of subjects. Characteristic statements in favor of more economics were the following:

"We heartily agree with you that agriculture students generally need more economics and social science in general than the normal agriculture curriculum requires if they are to face with any degree of adequacy the complicated policy problems they are likely to meet as soon as they enter practical life."

"We agree heartily that agriculture students need more good training in economics. This is true everywhere but especially true in our part of the country where farming is changing rapidly."

"The fields of orientation and production economics are particularly in need of strengthening, not only in our own country, but more for the nations of Europe, Asia and South America. In fact, I believe that if there were some way to make these things plain to the governing elements in those countries, we would

see a revolutionary change in political attitudes that would nullify communistic propaganda."

The questioning as to the width of the range took the following forms:

"Black's counsel is one of perfection. My experience with a 'six-credit course in which general economics and agricultural economics are interwoven' leads me to believe that only about half of Black's material can be included in a six-credit course. Extensive reading not supported by classroom discussion could be used for purely factual material, but not for revealing insights, upsetting folklore, and provoking thought, as I assume Black would wish."

"I gather that you share my feeling that a beginning course in Principles of Economics ought not to be weighted too heavily with theoretical concepts which are largely meaningless to the beginning student but instead should strive to develop a better understanding of the economic world in which we live and the operations of economic principles in that world. The major point of difference between you and me may be our expectations regarding the coverage of such a course in principles. We give consideration to the fields you mention in your article, but we do not think it possible to give very many students the comprehensive view which your review suggests. We believe it is necessary for students to follow the course in principles with a number of specialized courses in order to acquire a real grasp."

"While I thoroughly agree with you on the need for additional training of agricultural students in economics, it is impossible for me to say if the amount of training you suggest can be included in a regular four-year college course. Frankly, it appeared to me that you have suggested training almost to the extent which I received by majoring in agricultural economics for a Master's degree. Of course, I know that the general level of college work is moving up rapidly and it is possible that you did not intend that these courses dig quite as deeply as is necessary in graduate training."

"I wonder whether all of the subjects outlined can be handled completely in a six-credit course. It seems to me that the fulfillment of such an ambitious program would require graduate study in agricultural economics. Every student in agriculture is faced with the problem of allocating his scarce resources to maximize the product of his college career. Hence it is likely that no more than six credits of work in economics can be required of him. Similarly the teacher of economics must exercise choice in the subject-matter to be treated in such a six-credit course so as to maximize the student's comprehension of economic subject-matter. Because of the differences which exist among academic institutions I doubt if any one formula might be suggested as being the absolute ideal. However, I think it is extremely desirable to call attention of academicians to the significant variables involved in this problem of teaching economics to agricultural students, and to the alternatives that are available. Then in each case the institution concerned can make a well-informed, responsible judgment of the course of action it may wish to follow in meeting the needs of its students."

The last of these statements pretty well covers the situation. There is a choice to be made between selecting a few topics and analyzing these intensively in all their refinements, and selecting a larger set of economic

principles and relationships and driving the fundamentals of these deep into the thinking patterns of the student. Courses in principles may easily have been doing altogether too much of the former in recent years. It is equally possible that the required economics outlined in the article is a larger body of principles and relationships than can be driven as deeply as needed.

Fundamentally the issue is as simple as this: Will the required courses in economics for agricultural students include nothing whatever in the economics of land use, or land tenure, or agricultural credit so as to allow space for the refinements of the marginal analysis or of monetary theory? Or will they devote the equivalent of eight or ten pages in a textbook to the basic facts and principles of each of these and omit such refinements as the foregoing?

How Organized

The previous article concluded with a listing of three ways in which the required economics could be organized, namely, 3 credits each of general principles and general agricultural economics, 6 of the first and 3 of the second, or a 6-credit course in which general and agricultural economics are interwoven. Following is a cross-section of opinions on this subject:

"Of your three proposals, the second would have the most application here. This would mean that the economics department would have to develop a 2-term course in general economics to take the place of the present 3-term course. If this were done it would leave room for a third-term course in which the subject of agriculture would be uppermost in the application of economic principles to our general field of agriculture. This would probably be a more popular course than the third term of general economics as now taught."

"My own feeling is that there would be a real problem in giving the various phases of economics listed the balance necessary to bring students to the perspective your paper indicates they should have. If this be the case the next step is to determine the importance of subject matter and establish the level at which each topic would be discussed. Once this has been done it would seem appropriate to undertake the job of putting the material into a text that would become the basis for teaching a course such as you recommend."

"Personally, I prefer the third plan listed, namely, that of a six-credit course in which general agriculture and agricultural economics are interwoven as outlined in your article."

"The reprint of your article, 'Required Economics for Agricultural Students,' has been read with interest by several members of our staff. They agree with you that agricultural students should have courses in economics—but with an agricultural slant, such as would be given in an agricultural economics course, rather than the usual University course in General Economics. As to the academic pattern which the course should take, they favor No. 3 under 'Conclusions' in your article: a six-unit course given by an agricultural economics department."

"In general, I am in agreement with your analysis and conclusions. For preference of the alternatives which you set up, I would choose three—a six-credit required course in which general economics and agricultural economics are interwoven. This undoubtedly will require a very close working arrangement between the departments of general economics and agricultural economics."

"From my own experience, I would choose your alternative No. 3, requiring a six-credit course in general economics and agricultural economics, so interwoven as to give the student an overall perspective of how agricultural economics fits into the broad general economy of the nation and the world. The task, then, is not so much one of seeking new fields, but rather one of finding the right combination of subjects which will equip the student for the society in which he suddenly finds himself upon graduation."

"The advantage of your second proposal is that many courses in economic principles cover 6 credits. Therefore to take 3 credits of such a course will not only be inadequate background but will create a bad impression on the student's mind and curiosity. However, to allow more than 6 required credits will probably meet with opposition from the physical science faculties because of their crowded programs for majors. This is a strong argument for your third proposal with the reservations previously stated, that the course be not too agricultural."

AGRICULTURAL POLICY AND FARMERS' FREEDOM: A SUGGESTED FRAMEWORK*

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STUDENTS of American agricultural policy spend much time and effort in attempting to rationalize the apparently irrational value systems of the American farmer and his representatives as displayed in their political actions and attitudes. We are confronted with a group who seem to place the highest value on individual freedom and yet periodically vote into effect controls that put rather stringent restrictions upon their freedom to determine the amount of a crop they may plant or sell. Some explanations of these actions have been attempted, but as yet none has been completely successful. It is suggested that none is likely to be that is cast within the popularly accepted theory of social values,[1] and that there is a sound theoretical framework somewhat akin to that used in economic theory[2] which will provide a much more useful approach in our analysis of social values and political policy.

This matter is of more than academic interest at the present time. After twenty years of agricultural policy which often has been cited as a menace to farmers' "freedom" we have a new administration in power, one which wishes to make certain that the farmers' "freedom" is maintained. Yet it appears that farmers may not be as anxious to maintain this freedom as some have thought, if the political reactions of farm-state congressmen are any indication of farmers' attitudes on the subject. At the time of this writing farmers have been asked to choose between further restrictions on one of their "freedoms" or drastically lower price supports for wheat, and they chose less freedom. Other such decisions are likely to face them in the near future. Will this be an indication that farmers have abandoned their freedom in order to get higher prices, thus completely reversing the position that the leaders of the two largest farm organizations have supported so strongly from 1946 through 1952? It is suggested that the answer is no. These apparently erratic fluctuations of our agrarian society

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[1] See Gunnar Myrdal, *An American Dilemma,* Harper and Brothers Publishers, New York, 1944, especially pp. xlvii and xlviii and Appendix I.

[2] See J. R. Hicks, *Value and Capital,* Oxford University Press, 1948, Chapter I or M. W. Reder, *Studies in the Theory of Welfare Economics,* New York, Columbia University Press, 1947.

can be explained within a rational framework. An understanding of this framework is necessary at a time when new policies are being formed.

A Working Definition of Freedom[3]

In order to discuss the concept of freedom in relation to agricultural policy an attempt must be made at some definition of freedom. First, it should be recognized that no one is completely free, and therefore "absolute" freedom is not meaningful to this discussion. There must be some method of evaluating whether a particular policy leads to a reduction of freedom or an increase in freedom. For this particular discussion we shall be concerned about the state of freedom of the individual farmer in the operation of his farm.

To begin this definition of freedom it is suggested that an individual is free when he is able to do an act or not to do an act. Notice that this concept of freedom implies both his *ability to choose* to do an act or not to do the act, and the actual *ability to carry* out that act if he should choose to do it or not do it. Certain restrictions may be placed on an individual's freedom, and freedom is reduced or removed if these restrictions are present in a given policy. A common restriction is the loading of the consequences of doing an act or of not doing an act in such a manner that it will cause a person to choose a course of action that he would not otherwise choose. Accepting this broad definition means that the consequences of all acts are loaded in a price system since any price loads the consequence of doing or not doing an act involving production. It seems an unrealistic assumption to say that all prices are a restriction on freedom; and therefore, it is suggested that the consequences are not loaded unless there has been a conscious attempt by individuals or groups to apply coercion to specifically influence an act under consideration.[4]

Another restriction on freedom of the individual may result because he lacks knowledge of all the alternatives which are open to him or knowledge of the consequences of all these alternatives. However, it is obvious that full and complete knowledge is impossible. Therefore, everyone has certain restrictions on freedom and it is necessary to modify the definition so that it becomes meaningful. For this purpose it is suggested that the individual is free if he has a knowledge of the important alternatives that face him and the consequences of these alternatives relevant to the

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[3] The author has drawn upon ideas developed by Professor H. S. Leonard, Head of Department of Philosophy of Michigan State College, in a paper presented to the Seminar on Freedom, and Frank H. Knight, *Freedom and Reform*, Harper and Brothers, New York and London, 1947, especially Chapter I.

[4] Under this definition penalties for overplanting marketing quotas that reduce acreage below intentions to plant are restrictions on freedom, but actions of traders on the grain market would not be unless they attempted to corner the market.

rational formation of that particular decision. With this somewhat oversimplified definition of freedom, let us proceed to a discussion of freedom and agricultural policy.

Just as there is no such clearly definable concept as complete freedom, neither is there any meaning unless we are discussing a specific freedom to do something. Since most of the discussion of freedom and agricultural policy seems to revolve around the relationship of the federal government and the individual farmer, this discussion will be primarily concerned with the policies of the government as they have affected or may affect the individual farmer *in the operation of his farm.*[5]

At this point in the discussion it is useful to stop and point out that there are a number of other social values held in our society which have entered in the formation of agricultural policy and which may come in conflict with freedom.[6] In the field of agricultural policy the more important values that might be listed are family farm ownership; equality, which may at times be called justice and has come to be known at present as parity, but which is essentially a concept of real farm income; and the value that we place on economic efficiency. Another value which has become more prominent and which probably should be added to the list is the value of stability or security. At various times different public programs attempt, or are developed in an attempt, to increase or improve the attainment of these social values. Sometimes the attainment of several of these values coincide and any one program may increase or help achieve a fuller attainment of a number of these values. At other times a program designed to attain one of these values may conflict with other values, and in many cases such programs may conflict with the freedom of the farmer to operate his farm.

The idea that there are a number of values which conflict with freedom is not a new one; however, it does seem that there has been a lack of clarity regarding the point at which these values conflict. It has been pointed out that there is no such thing as absolute freedom, and this is true of all of the other values under discussion. In order to be meaningful, we should realize that we are discussing these values in marginal terms only. This is extremely important for several reasons.

The first reason is the relationship of marginal social values to the political compromise. Our political parties are famous for the marginal compromise they make in order to gather the support of minority groups, to the dismay of the advocates of programmatic parties. Perhaps to some

[5] This rules out of this discussion the effects of a tight monetary policy or progressive taxation, although the same theoretical framework seems applicable with some alterations.

[6] See the article by D. E. Hathaway and L. W. Witt, "Agricultural Policy: Whose Valuations," *This Journal,* August 1952.

these compromises may not appear marginal, yet neither major party would ever admit that they had drastically reordered their principles to collect the groups that make up their parties. If we were dealing with absolute values, political compromise would be unlikely if not impossible unless major portions of society were willing and able to reorder their entire value systems in a relatively short time.[7] This is probably impossible under a rational democratic system of government and would probably result in revolution over numerous issues if it were necessary. In fact, we have seen one instance in our history when the value conflicts involved such large marginal increments of so many values that a major portion of society would have been required to drastically reorder their value systems to live within a new national policy. They refused to do this and a civil war resulted.

Another reason that social values must be considered in marginal terms is directly related to the first. If discussions are in terms of absolute values and their conflicts it becomes important to determine the ordering that an individual places on these values and aggregation becomes difficult if not impossible. Then if people seem to desire programs that conflict with this ordering it is assumed that there must be either a group of conflicting absolute values which persons fail to recognize in their conscious activities or that there is a continuous and frequent reordering of the various social values. This has been a favorite subject of many authors who accept the first assumption as true. It is suggested that neither assumption is necessary and that the use of the marginal concept is much more useful and meaningful.

By using the marginal concept it can be perfectly rational for an individual to hold freedom as his highest value, even above life itself, and still be willing to sacrifice some small portion of his freedom in order to achieve more security. This involves only marginal rates of substitution between the values and easily serves to explain why persons make different choices at different times without the confusing problem of trying to explain why there were changes in the total value systems of a society.

Viewing these conflicts between values as marginal conflicts has another usefulness in light of our discussions of agricultural policy. It seems that two or more of these values which may conflict when considered in an absolute sense are probably complementary for certain ranges at their margins. Thus we can have programs which increase both freedom and security within certain ranges, which if carried to extremes would result in a decrease in one or the other.

[7] Most authors say either that this is true or that there exist higher values to which persons turn when value conflicts occur, but these higher values are rarely defined. Neither explanation seems satisfactory and both can be avoided if we abandon our concern regarding the ordering and conflicts in absolute terms.

The framework of marginal substitution of social values not only seems to avoid confusion in discussion, but the concept also has the advantage of diagrammatic expression.

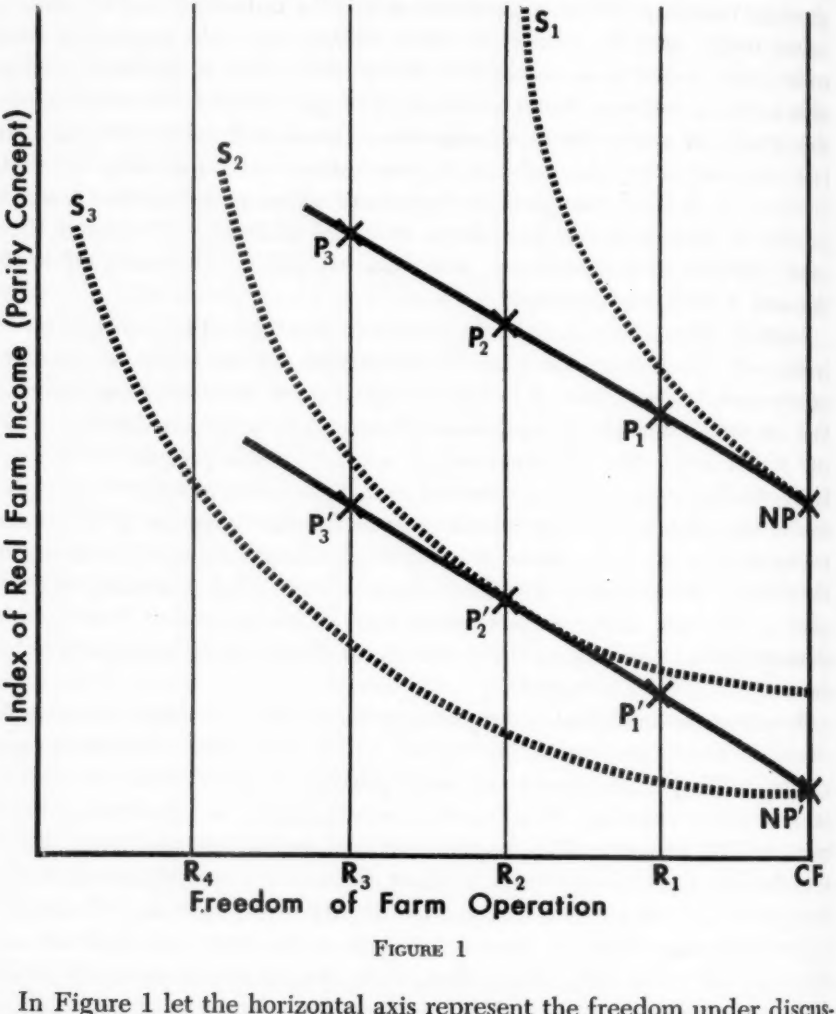

FIGURE 1

In Figure 1 let the horizontal axis represent the freedom under discussion, in this case the freedom of farm operation. At point CF the farmer has complete freedom from government interferences in the operation of his farm and points R_1, R_2, R_3, and R_4 represent successively greater government restrictions on the freedom of the farmer in the operation of his farm. On the vertical axis let us have a scale representing an index of real income to be expected from the crop under discussion, which is closely related to the farmers' concept of parity and equality.

Now let us add a series of curves which indicate the pattern of the marginal rate of substitution that a farmer has between the value he places upon freedom of farm operation and his real income position in society. For lack of a better name, these are called "satisfaction" curves and the individual farmer is more satisfied on curve S_1, than S_2 or S_3. However, the level of satisfaction which he may attain regarding the two values under discussion is determined in large part by forces beyond his control, i.e., the market for his product and the possibilities of market manipulation via government intervention.

Thus, at point NP there is no program and the farmer has complete freedom of farm operation, at point P_1 there is some restriction of freedom and the income position is higher, at P_2 there are even more restrictions on freedom and a higher income position, and at point P_3 there would be greater loss of freedom of farm operation and a somewhat higher income. Given the income possibility line just described the farmer would receive the most satisfaction with no government program since he could attain satisfaction curve S_1 from the free market. This situation undoubtedly represents the position of most farmers in the early post-World War II period. At that time no support program offered to farmers could improve their income position enough to get them to accept the accompanying controls.

Now let us turn to a market condition illustrative of the 1953 wheat market. The market price in the absence of a government program would result in income NP′ which would place the farmer on the lower satisfaction curve S_3, but the farmer knows or believes he can improve upon this position by accepting control program P_2' which places him upon satisfaction curve S_2. Thus, farmers may vote a control program into effect for a commodity *without any change in their social values regarding freedom,* merely because their income or total welfare possibility line has moved sharply to the left due to changing economic conditions. Where at an earlier time he was willing to sacrifice very little freedom to receive increased income, he now is ready to sacrifice some freedom of farm operation to improve his income position.

It can be readily seen that the characteristics of the income possibility curve and the satisfaction curves are extremely important in the formulation and acceptance of agricultural policy. Regarding the income possibility curve, it can be reasoned that the slope of that line would be closely related to the price elasticity of products under discussion. This, of course, seems to explain why products for which there is a relatively inelastic demand would come under control programs at an earlier time than would those with a more elastic demand, since the slope of the income possibility line would be greater and thus the point of tangency

with a satisfaction curve involving some loss of freedom would come earlier, unless the satisfaction curves are very flat.[8] The amount that the income possibility curve shifts with changing economic conditions depends, of course, upon the income elasticity of the products being discussed.

There is less to indicate the shape of the various individual farmer's satisfaction curves that represent the marginal rates of substitution between these social values. Obviously, some persons place an extremely high marginal value on freedom of farm operation regardless of economic conditions and would have very steep curves, while others are willing to sacrifice some freedom to gain greater income regardless of how high incomes are at the time and would have very flat curves. It appears likely that the lower curves would tend to become flatter for all farmers.

Given the income possibility curve and the satisfaction curves for the individual social values, a program will be adopted (or desired) whenever the income possibility curve is tangent to a higher satisfaction curve of a majority of the farm population than the satisfaction curve they might attain without such a program.[9, 10] Thus two conditions could bring about sharp shifts in farmers willingness or desire regarding certain types of programs. One would be due to a shift in the income possibility line, due either to changing economic conditions or to the advent of a new program that gives greater incomes with the same restriction of freedom. Another shift could result because of a change in the satisfaction curves (marginal rates of substitution) of farmers who had become irritated with government controls or because of a basic change in their value systems due to the impact of new ideas or facts. However, it would seem that

[8] The elasticity of demand for the product is also closely associated with another major value sought by government programs, the value placed upon income stability. A third value cannot be shown on our diagram, but the complete determination of the individual's satisfaction surface depends upon the simultaneous solution of a system of equations representing the marginal values of all of the social values concerned in a given program.

[9] This assumes that the political processes work well enough to establish such equilibrium. If the political leaders do not correctly appraise the situation, they may be changed. In the meantime the income possibility curve may move even further to the left as conditions get worse. Thus a mild control program at one time might make a stricter program at some later time both impossible and unnecessary.

[10] This seems to avoid the problem of aggregating individual orderings of these social values which has been discussed at length by Kenneth J. Arrow in *Social Choice and Individual Values*, John Wiley and Sons, Inc., New York, 1951. In general our voting processes consist of two phases. In an election we vote "yes" or "no" for an individual and attempt to vote yes for the one that we believe has approximately the same rates of marginal substitution between social values as we have. A congressman voting in a committee or an individual farmer voting on wheat marketing quotas votes yes or no on a specific proposal. The farmer does so in regard to his own satisfaction surface and the congressman does so in line with his estimation of the satisfaction surfaces of a majority of his constituents.

the latter type of changes would occur slowly and that our apparently rapid changes in farmers' attitudes consist of changing income possibility curves relative to fairly stable satisfaction curves.

It is suggested that this type of framework can also be useful in understanding attitudes and political actions toward other phases of agricultural policy than price supports and production controls. This would require some redefinition of terms and relabeling of axes for the diagram, and will be impossible due to the lack of space in this discussion. Let us turn now to the history of the 1920's and 30's to see if this theoretical framework helps to explain the political action of farmers and their organizations.

Agricultural Policy and Farmers' Freedom—1920-40

Numerous discussions are available on the reasons for the problems that beset agriculture starting in the 1920's. These will not be covered again since it has been stated that the effects of the price system on agriculture are not regarded as constituting a restriction on freedom of the individual farmer. To view the price system as a restriction on freedom of farm operation makes the whole idea meaningless, and as mentioned before prices will be viewed as a restriction on freedom only in cases where there has been concentrated coercion to specifically drive down individual farm prices. A farmer's lack of knowledge that a specific price decline is coming may be a restriction on freedom, but no more than is his lack of knowledge of a forthcoming price rise a restriction on freedom. For this reason, low farm prices in relation to other prices is viewed as an income equality problem in most cases.

In the early 1920's the problem was not of agricultural freedom, but one of achieving equality of income for agriculture. It is interesting to note two other developments of that time. The first was that throughout the 1920's many agrarian groups were clamoring for equality, for protection of the family farm, and suggesting restrictions on the freedom of the individual farmer in the form of production controls. At that time the executive branch of government refused to interfere with the freedom of the individual farmer in the operation of his farm. In fact, the only programs that the executive branch seemed willing to carry out were those that would increase the freedom of the farmer through the extension of knowledge, more research and discussion of better marketing methods. Thus, we had two major policy making groups within our society with sharply differing marginal rates of substitution between these social values. The executive branch of the government apparently regarded freedom of individual farm operation very highly and refused to restrict it regardless of the effects that the lack of a positive policy was

having on the other values held by farm groups. At the same time some farm organizations and many other representatives of farmers, including many congressmen from the so-called farm bloc, were demanding government programs that would increase or help achieve equality for farmers at the sacrifice of some of their freedom.[11] The result of this conflict was a long period of inaction during which agriculture suffered a great deal.

Conditions in the early 1930's became much worse,[12] and starting with the advent of the New Deal there was action, a great deal of action, for a number of reasons. One reason was that the new leaders that came into power in the executive branch of the government were those whose estimates of the relationships between the various social values more nearly coincided with those of a majority of the public at that time. Secondly, the economic and social conditions of the great depression had altered the income possibilities from the unsupported market so drastically that policies which previously had no possibilities of acceptance were readily adopted. With a major portion of our resources unemployed efficiency became of little or no concern, even among economists. Thus, in agricultural policy there was action as inequality became greater, family farm ownership was threatened, and the security of agriculture was impaired. At that time a policy to achieve these values was complementary, and there was no widespread protest from the agricultural sector of the economy when freedom of farm operation was restricted and production control for agriculture was inaugurated on a widespread basis.[13] Of course, this phenomenon was true throughout the economy in general, and we found that the early programs of the New Deal were largely those which attempted to increase income equality and security, and many reduced individual freedom without a great deal of protest from any segment of society.

In the area of agricultural policy the restriction of the farmers' freedom came primarily via the loading of the consequences of producing certain crops. These consequences were loaded by the making of or withholding of certain types of payments by the government. This type of activity was found unconstitutional and was replaced by another activity under the Soil Conservation Act of 1936, which essentially was still a loading of the consequences of growing certain "soil depleting" crops.

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[11] Another reason for the divergent attitudes may have been different opinions as to the income possibility line with no government intervention or with various types of programs.

[12] Primarily because the income possibility for agriculture was so poor without government intervention.

[13] It is entirely possible that conditions were bad enough that the income possibility curve became concave to the lower areas of the income and freedom scales on the diagram shown in Figure 1.

In the Agricultural Adjustment Act of 1938, certain provisions were established which could be severe restrictions on the freedom of farmers in the operation of their individual farms. Again these activities take the form of the loading of the consequences of growing or of not growing certain crops. The mildest form of these restrictions is the acreage allotment, in which the consequences are loaded by the withholding of government support prices from the farmer who fails to comply with his acreage allotment. If the price support program in operation is very effective, these consequences may not be at all severe since the market price may approach the support price of the government program. However, the Agricultural Act of 1938 also included provisions for marketing quotas, which may be a severe restriction on the freedom of the individual farmer, since it puts rather substantial cash penalties on the production of crops on acreage in excess of the farmer's allotted acreage. Both of these forms of restriction of farmers' freedoms were used for several crops between 1938 and 1942.

It is doubtful that these severe restrictions on the freedom of the individual farmer in the operation of his farm could have been written into our agricultural policy at that time without the consent and approval of the major farm organizations. This does not suggest those organizations had lost their high regard for the freedom of farmers during that period. However, they were willing to sacrifice some freedom of farm operation in order to gain more of other values.

It should be pointed out that these severe restrictions on farmers' freedom (marketing quotas) can only be put into effect after the affirmative vote of two-thirds of the eligible farmers who vote. If the Secretary of Agriculture should request marketing quotas and the eligible farmers fail to approve the quotas, the support price on the crop in question is lowered drastically or removed entirely. Thus, by this vote farmers are essentially asked to choose between a promise of higher incomes and more security, or more freedom. Since the authorization of marketing quotas in 1938, the tobacco producers have voted affirmatively on marketing quotas in every year except one. This seems to be a definite indication that this group places a higher value on what they believe to be an increase in security and equality of income than they do on the increased freedom they might gain from an unsupported market. Recent research by Glenn Johnson[14] indicates that they have been quite successful in achieving their desires since the program has apparently resulted in real gains to the producers over a free market.

The 1938 Act also authorized the use of other restrictions on the

[14] *Burley Tobacco Control Programs,* Bulletin 580, Kentucky Agricultural Experiment Station, February 1952.

freedom of farmers and marketing agencies; namely, marketing orders and agreements. These load the consequences of marketing certain classes of products. Like the marketing quotas they require an affirmative vote of the producers or marketing agencies dealing with the commodities. These devices have been used widely on a number of perishable commodities, providing many examples of where a majority of the persons involved have been willing to sacrifice some freedom for what they thought might be additional equality or security.

Thus, as we moved through the 1930's, there seemed to be a tendency to evolve agricultural policies that authorized greater and greater restrictions upon the freedom of the individual farmer in the operation of his business. The major value that farmers and their representatives seemed to be seeking to achieve during those years was equality for agriculture. Throughout this period farmers sacrificed freedom in an attempt to achieve higher prices because through these programs they could achieve a higher level of satisfaction than was offered by the uncontrolled market.

Freedom and Postwar Agricultural Policy

By the end of World War II the problem of equality of income for American agriculture or at least for the commercial farmers had been solved by high farm prices. At the same time the capital structure of commercial agriculture resulting from these prices was such that they had made rapid gains in efficiency of production. The status of the family farm was well established and most commercial family farms had never known a state of prosperity as good as that in the postwar period. This meant that the market was satisfying, to a large extent, most of the major values that are desired by the important groups in the agricultural society. Most farmers were willing to sacrifice very little freedom in order to gain any more security, because the income possibilities from the free market placed them far to the right on their indifference maps and additional security or equality from government programs could not improve their position.

During this postwar period the leadership of the largest farm organization, the American Farm Bureau Federation, came to men who believed that equality, efficiency, and freedom came through a free price system. Thus the weight of the organization was behind a rate of substitution that placed an extremely high marginal value on the freedom of the individual farmer to operate his farm, and there came strong demands for more freedom for farmers and a willingness to take lower price supports to achieve their goal. The leadership of the political party in power at the time was a man who apparently placed an extremely high marginal value

on equality, and the Secretary of Agriculture, a major force in the formulation of new agricultural policy, also seemed to think farmers would be willing to sacrifice some freedom to get additional security and income.

The greatest clash of these two conflicting views came over the Brannan Plan, which was proposed by Secretary of Agriculture Brannan in 1949. The controls that Secretary Brannan proposed were the ones that had been written into law in 1938. He did not propose any new controls and said he wished to avoid the use of these controls as much as possible. Not only did the law contain no new controls, but it is doubtful that even the high level price supports which Secretary Brannan proposed would have required any more production control at the present time than the lower level of price supports required during the 1930's. Thus, it is suggested that the Brannan Plan was not any more serious threat to the freedom of the farmer than were many of the programs that were actually in operation during the great depression. However, due to the drastic differences in the income possibility position of farmers and the resulting changes in the marginal rates of substitution between these values among farm people and their leaders between 1938 and 1949, freedom appeared a more important value by 1949 and there was a great hue and cry over the farmers' loss of freedom under the Brannan Plan, The Agricultural Act of 1949, and recent amendments to that Act. Thus, we find ourselves at a time when there is a widespread discussion of farmers' freedom in agricultural policy, and the relationship between high supports and strong production controls.

The increased emphasis on freedom in our present policy discussions does not appear to be the result of an attempt to impose new and invidious forms of government control upon the farmer. Rather, it is the natural result of a sharp clash between groups which have differing ideas as to the marginal value of freedom and the other social values. It is not surprising then that the new Secretary of Agriculture in his first policy statement, of three and a half pages, mentioned the word "freedom" *six* times and "free" *five* times, while his opponents in Congress and some of the farm organizations demand higher supports to guarantee farmers "fair" prices and incomes.

If the recent vote on marketing quotas for wheat and the political pressure brought to bear upon Secretary Benson regarding price supports for butter and beef are to be judged as representative, there are strong indications that farmers' positions regarding government controls and government aid are again changing as their income possibilities change. Thus we may be confronted with the interesting spectacle of two successive Secretaries of Agriculture who are plunged into political hot water

by the shifts in farmers' marginal rates of substitution between these social values. On one side was Secretary Brannan who offered an income possibility line at a time when the market placed farmers on a satisfaction curve so far to the right that no program containing production controls could reach it and be acceptable, and now Secretary Benson who wants to withdraw from such activities when the market places many farmers on a much lower satisfaction curve and when farm people know there are possible programs which they would accept to maintain farm prices. Oh what popular figures these men might be were their positions reversed!

Empirical Investigations and Policy Implications

At this stage of generalization the author, at least, is willing to conclude that this theoretical framework does seem to offer a rational explanation of social values and political actions of our farm groups. In addition, however, it seems to be useful in another way in that it appears that the positions of these curves and income possibility lines is within the realm of possible empirical verification, an attribute not easily found in the present framework.

To suggest some of these possibilities and what they might entail let us turn again to the diagram, Figure 1. This discussion will be much like the first, only it shall be in terms of a specific problem. For that problem let us tackle the problems of support programs for wheat and the control programs that seem an inevitable accompaniment.

On the vertical axis let our scale be in terms of the real income to be realized from wheat production. Let the horizontal scale be some measurement of the farmer's freedom to operate his farm, pertaining specifically to the production of wheat. At point CF the farmer has complete freedom to plant all or none of his farm to wheat, to use any production practices, sell any amount he wishes, within the uncertainty of free market prices for wheat. At the other end of the scale, R_4 is the point where the farmer is given a bushel allotment of wheat he can sell and the use of excess acreage is controlled; this representing about the greatest restriction on freedom of farm operation that can be visualized under our present programs. Between these two extremes are three other possible points that represent varying restrictions on freedom of farm operation: acreage allotments without any penalty other than loss of full support guarantee, R_1; marketing quotas which merely enforce acreage allotments but allow improved production practices, R_2; and marketing quotas in bushels which prevent the use of improved practices, R_3. The relative position of these points along the line would be determined at the same time as the program possibility line and would be somewhat variable for indi-

viduals because of rotations, feasible alternatives, and individual preferences; but in general their relative positions would be highly dependent upon the physical acreage or bushels reduction necessary to achieve the desired gain over free market incomes. In the aggregate this depends, of course, on supply-demand analysis of given conditions.[15]

The present methodology in agricultural economics research has advanced to the point that the empirical determination of the income possibility lines for various agricultural commodities is now possible. At present very little of this type of analysis has been done, at least for presentation to the general public of farm operators who are forced to make important policy decisions on the basis of little or no information regarding the true income possibility lines. Certainly the farmers are to be blamed less than the professional economists if the farmers vote programs into effect that reduce their freedom of farm operation because they have incorrect or no information regarding their true income possibilities under other alternatives. There is certainly much to be achieved before the profession has fulfilled its role in aiding farmers to achieve their maximum satisfaction position from agricultural policy. To claim that farmers have the wrong marginal rates of substitution between social values is not the answer!

The determination of the satisfaction curves of the farmers is important and depends on carefully conducted interviews with farmers. If farmers were asked a series of questions—"Would you vote for marketing quotas on wheat which reduced your acreage —— per cent in order to get —— cents per bushel higher than the free market price?"—for each type of controls, a series of points on that individual's satisfaction curve at that time could be approximated.[16] Thus at any given time it would seem possible to determine from a sample of farmers whether a given program would be acceptable to farmers, giving us among other things some measurement of how well our normal political processes are functioning in the development of agricultural policy. Such investigation might also help isolate some of the factors influencing the different marginal rates of substitution of social values between individuals, certainly an important

[15] For a program such as the tobacco program to work as well as it does administratively, approximations of this analysis must be made each year, at least on an informal basis. Of course, if we assumed that the government would continue high-level supports without production controls there would be no loss in freedom to the farmer in the context we are using, in fact there might be a gain from the added price certainty. Unfortunately (or fortunately) our present programs call for production controls, and unless our policies undergo some rapid changes these controls are likely to continue.

[16] If the individual had a zero marginal value for freedom of farm operation this should approximate a constant income curve. It is assumed that this would not be the case, although such a curve might be a good point from which to start.

addition to our understanding of agricultural policy and its formation.

To return to practical policy, it appears that Secretary Benson faces a tremendous problem in his attempt to change the direction of our agricultural policy during a period in which the income possibility line for farmers is shifting rapidly and bringing forth different marginal rates of substitution for these social values among farmers. A change in policy in the face of declining agricultural prices may not be possible immediately, but it is important that our policy-makers understand what must be done to have a new policy accepted.

Above all, it seems important that we do not accuse farmers of having traded their birthright for a "mess of pottage" until we know more about their basic value systems and satisfaction surfaces and ways to bring these substitution rates more nearly in line with those of our society as a whole.

AGRICULTURAL INTEGRATION IN EUROPE

J. H. Richter*

INTEGRATION has become something of a slogan for democratic Europe's survival. It is being sought—with ups and downs in emphasis, with more or less enthusiasm—in the general political field, in defense, and in economic affairs. With roots in the prewar movement of Count Coudenhove-Kalergi's Pan-Europe, the postwar world has seen the establishment of the Council of Europe at Strasbourg, made up of parliamentarians from all West-European countries, thus far an academic effort at the formation of an all-European parliament; of the Organization for European Economic Cooperation (16 countries plus overseas territories) and the European Payments Union; of the European Coal and Steel Pool (6 countries); and of the North Atlantic Treaty Organization (with mixed European and North-American membership). Plans are being laid for a European Defense Community including a European army, and for a European political federation.

Since 1949-50 discussions have been held and projects have been examined for *agricultural* integration in Europe—a "Green Pool," as it is sometimes called, that would aim at unification within western Europe of the markets for agricultural products and rationalization of methods and location of production for a consolidated, strengthened, and—if possible—guaranteed European market.

The theory on which the efforts in all these fields are based is simple. It is, above all, the realization that the countries of western Europe have a common culture and political philosophy that they wish to preserve; that these ties are stronger than what still separates them from one another; and that their combined strength will be greater than the sum total of their individual capabilities of maintaining and advancing their freedom and prosperity. At this point, and with respect to their belief in methods of achieving the end of integration, the various schools part ways.

Some of them do not think complete integration is necessary or even desirable; some sort of *economic* union or cooperation is all that this group seeks or considers realistically possible. Another group believes that, short of complete *political* union, under one government, nothing really substantial can be accomplished in the field of economic integration. Still another group believes that complete political union is not a realistic expectation at this moment but that—if the way is paved by a growingly

* Foreign Agricultural Service, U.S. Department of Agriculture. This article expresses the personal opinions of the author and does not necessarily reflect officially accepted views or interpretations of the subject.

inextricable network of partial economic integration schemes—general economic and political union will be the natural outcome of this process of gradual approximation. It is the latter school of thought that has fathered the proposals for agricultural integration in Europe.

Integration in Agriculture

There have been varying presentations of the idea of European agricultural integration since it was first broached between the French and German farm leaders at the General Assembly of the European Confederation of Agriculture at Innsbruck (Austria) in September 1949, and again in June 1950 at the Conference of the International Federation of Agricultural Producers at Saltsjobaden (Sweden). Its theoretical and practical outlines still show considerable divergence of concepts and plans. At one extreme there was first an orthodox concept, concentrating on complete unification of all agricultural markets and prices throughout western Europe, hence also on relocation of production, elimination of inefficient producers, and rigorous pursuit of productivity, with a supra-national authority vested with powers to dictate to governments the enforcement of these goals. At the other extreme stood a restrictive plan aimed at sheltered marketing agreements across borders, "buy European" policies, indefinite protection of inefficient farms through subsidies if prices were to be lowered, and "graduality" of integration concentrating on 2 or 3 products first, with an international advisory board to coordinate such cartel-like arrangements.

Neither of these extremes appeared to be suitable as a basis for further study, and the working assumption that has implicitly guided the debate of the past two years may perhaps be characterized by three major points: (1) gradual alignment of markets for *all* agricultural products; (2) some relocation of production to increase all-European productivity in agriculture, with gradual elimination of the most inefficient producers; (3) these goals not to be left to the operation of the blind forces of a unified uncontrolled market, but to be pursued in orderly fashion with the help of the national authorities and of a supra-national authority pointing the direction in which national adjustments should proceed, and aiding with adjustment subsidies, marketing arrangements, perhaps intra-European long-term contracts, and promotion of technical progress. Moreover, the character of the supra-national authority envisioned would admittedly, at least for a long transitional period, be of the advising and helping, not of the dictating, kind.

It was on the basis of some such compromise idea that governments proceeded to discuss and study the possibilities for agricultural integration. And it was on this basis that their preliminary positions were formed.

Positions of Individual Countries

The only ardent advocate of a plan of integration that truly rests on economic principles is the Netherlands, spurred by its position as an efficient producer and exporter of agricultural products. Italy's position is also favorable to integration, in view of the country's important export interests and natural advantages for such products as fruits and vegetables. Italy stresses, however, that agricultural integration must permit agricultural labor to migrate across borders from areas of surplus labor to areas of labor shortage. France, one of the earliest advocates of integration—interested in a dependable export market for French wheat, sugar, and wines—has grown more reserved, but still supports the idea strongly. These three countries also accept the principle of a High Authority with supra-national powers.

In spite of strong farmer opposition, the attitude of the government of West-Germany is favorable to European agricultural integration. Emphasis is, however, on the requirement that integration should not be confined to just a few products nor to agricultural products alone. Denmark, after considerable hesitation, is not unfriendly to integration plans, but stresses the importance of coordination with United Kingdom policies. Norway and Sweden are either indifferent or cool to the idea of agricultural integration and Belgium is definitely reluctant. Switzerland rejects the proposal on grounds of overriding concerns of national interest, of the need to retain bargaining strength vis-a-vis her trade partners, and because it considers the plans as unrealistic and unlikely to prove politically acceptable to West-European democracies.

Greece and Turkey expect integration to provide favorable opportunities for the long-term placement in western Europe of their export products. The United Kingdom, the hub of a far-flung Commonwealth, while obviously not in a position of joining in integration with continental western Europe, has after initial aloofness now indicated that it would wish to cooperate and to support European agricultural integration—an important commitment in view of the huge capacity of the British market.

General Reactions

Attitudes of farmers and governments toward agricultural integration necessarily differ, depending upon the interests they represent. Progressive farmers favor integration. Other groups of farmers, notably those with high production costs, are definitely against it. It is pointed out that many small and very small farms, especially in countries that have always had high trade barriers, are not efficient enough to compete in a liberalized market. On the other hand, it is stated that a sizeable portion of the inefficient small farms is of the subsistence type that is only to a small

extent influenced by market developments and might benefit from integration with respect to some products as much as it might lose with respect to others.

There are also arguments of a sociological and general security nature. The maintenance of a reasonably large farm population is considered a prerequisite for the coherence and stability of society. Those countries that are so near the frontier of the Western World also insist that they must have a large and diverse agricultural production that covers a substantial part of their food requirements and in times of emergency could be made to cover an even greater part. Hence they are opposed to a scheme that, temporarily at least, might weaken the extent and diversity of their agricultural production. Integration in all segments of the economy presupposes readiness to sacrifice a measure of immediate welfare and security for greater benefits of this kind in the more distant future. It would therefore not be unnatural if, at a time like this, the present were considered more important than a future that might not come about at all unless the present is adequately protected.

On the other hand, observers in Europe realize equally well that not enough stress is being placed upon productivity and that it has been largely under the stimulating pressure of competition that agriculture in such countries as the Netherlands and Denmark has achieved its superior standards of efficiency. This point is also emphasized by representatives of consumers and industrial workers.

The attitude of industry and business in general on the question of agricultural integration has also been divided. French industries, for example, have expressed opposition to the plan, presumably in the expectation that it would lead to liberalization and hence increased foreign competition in industrial products as well. A foretaste of this possibility was given by demands on the part of farmers that, even within the agricultural scheme, imports of farm machinery and fertilizer should also be liberalized to bring down production costs.

German industry, on the other hand, has voiced its misgivings for precisely the opposite reason: that liberalization for agricultural trade alone would reduce the bargaining power of Germany, a large-scale importer of agricultural products and exporter of industrial products, without a compensatory reduction in barriers to German industrial exports.

Economic Appraisal

The economists' appraisal of the plan for agricultural integration has covered most of the points brought out by the general public's reactions to the scheme, but has also probed more comprehensively and more independently into its problematic character.

The most important comment finds expression in two arguments, the first relating to agricultural integration specifically, the second to European economic union in general. It is argued that, just as the integration of one or two agricultural commodities only would prove a failure, integration of one segment of the economy alone—agriculture—would not make economic sense.[1] It would add to rather than relieve existing economic imbalance, both internal and external. A reduction in tariffs and other restrictions on the movement of agricultural products across borders is always helpful. But a much more serious market problem of the European surplus producers is the fact that the United Kingdom and Germany may not be able to afford either a higher level of consumption or the foreign exchange needed for larger purchases. The same difficulty—that the agricultural problem cannot be considered in isolation—arises in connection with the relocation of production in an integrated Europe. In some countries, small producers of livestock products or of vegetables could not possibly compete in the larger arena. But if their labor could not be absorbed in other industries, it might—from the general economic point of view—well be cheaper to maintain them as relatively inefficient small-holders than as unemployed industrial workers.[2]

On the second point it is argued that the sacrifice of economic adjustments and relocations would, in principle, encounter the same kind of difficulties and opposition in the case of integration on a limited and preferential European basis as in the case of universal economic integration with the rest of the world, through restoration of currency convertibility, removal of quantitative trade restrictions, and limitation of tariffs. If the aim is a more productive economy and a better division of labor, universal integration would be vastly superior to a limited European scheme. Moreover, since universal integration is no doubt the ultimate aim of those who hope for a sensible economic regime throughout the world, the adjustments required by a European scheme would have to be, partly, undone when we tackle the restoration of all international trade on the basis of general convertibility and freedom from quantitative restrictions.[3]

It is recognized, of course, that liberalization of trade on a regional basis would call for a smaller extent of adjustment and relocation of production

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[1] Cf. H. Niehaus, in *Agrarwirtschaft*, April 1952 issue (Hanover, Germany). Also A. Hanau: "Preisprobleme einer Europaeischen Agrarunion," in: *Gutachten zu Fragen einer Europaeischen Agrargemeinschaft*, published by the German Foreign Office, Bonn, Germany, 1953.

[2] Cf. "Europe's Plan for an Agricultural Pool," in: *Foreign Agriculture*, Vol. XV, No. 11, Washington, D.C. Nov. 1951.

[3] Cf. E. Kueng: "Westeuropaeische oder universelle Wirtschaftintegration" in: *Aussenwirtschaft*, Volume 7, issue 3, St. Gallen (Switzerland), Sept. 1952.

than would universal liberalization. Therefore, the limited scheme, while essentially faced with the same type of political resistance from producers, might have a better chance of realization. But there is a danger that the effort spent on the limited solution might weaken and delay earnest attempts at a universal approach.

There is much new-fangled jargon to describe the simple and well-known content of a moderately liberal trade policy such as existed before the Great Depression of the 1930's. Could anyone realistically hope for a higher degree of economic integration, in the near future, than what Europe—and the world, for that matter—did have then without a supranational authority or elaborate organizational arrangements, simply by virtue of partnership in that trading system? The most realistic expectation, and at the same time the most optimistic, would be the degree of integration that would result from the gradual further liberalization of trade through elimination of quantitative restrictions and reduction of excessively high tariffs. Such a course would partly eliminate the great problems that the "one-price" idea of a common market would entail; the differences in prices of agricultural products as among European countries are, in general, formidable.[4]

Nevertheless, there is a good measure of opinion among economists in favor of pushing forward with concrete steps toward agricultural integration in an *organized* effort and as part of general economic liberalization. The abolition of barriers to intra-European trade would help in freeing consumer preference from distortions and should also help in reorienting agricultural production in the direction of comparative advantage, at least within the area limits. The subsidies for re-adaptation or more permanent support that would be necessary in a number of countries would be the lesser evil. From an economic point of view, producer subsidies are better or less damaging than prices artificially boosted by tariffs and other restrictions. Hence, on balance, the realization of the plan would still be a step forward in the rationalization of Europe's economic setup.[5]

It is also well understood that the movement toward European integration is primarily political, not economic;[6] it is the concept of a strong and united Europe that might open a new era of freedom and advancement that appeals to the imagination and hope of men. Hence, if specific steps must be taken toward "organized" integration, they might as well be taken judiciously and with economic common-sense.

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[4] Cf. W. Klatt: "Towards Agricultural Integration in Europe"; in: *The Twentieth Century*, Dec. 1951 (London).

[5] Cf. H. J. Frietema, address given at the Netherlands School of Economics, Rotterdam, November 23, 1950.

[6] Cf. P. Kuin: "Economic Integration in Europe," paper read before the *Vereniging Voor Staathuishoudkunde* at Utrecht, December 20, 1952.

It is in this sense that concrete proposals were recently made by Professor A. Hanau, the Director of the German Institute for Agricultural Market Research at Voelkenrode. As a move in the right direction Dr. Hanau considers that the intra-European trade liberalization scheme of the Organization for European Economic Cooperation (O.E.E.C.) should forthwith be extended to include, in the "common" list,[7] grain, butter, and cheese.[8]

Latest Developments

Following the so-called Preparatory Conference for European agricultural integration held in Paris on March 25, 1952, with participation of most West-European countries, a Preparatory Working Party, with subgroups, was set up to decide preliminary questions and to prepare voluminous documentation. Neither the first nor a second conference held by the Ministers of Agriculture in Paris in March 1953 made much progress toward a workable program. An interim committee was established for further exploratory inquiry and has since held several meetings. The discussion seems to have veered toward intra-European marketing agreements—the restrictive rather than the bolder economic approach.

However, as discussion among governments and experts has proceeded over the past two years, there have been a number of salutary adjustments in the Conference's attitude. It is now generally recognized that agricultural integration can only be contemplated as part of a general economic scheme. From the outset, the Organization for European Economic Cooperation has, in its efforts at gradual liberalization of intra-European trade through elimination of quantitative restrictions, insisted that this liberalization must be economy-wide and not confined to individual sectors. The Ligue Européenne de Coopération Economique conceives of agricultural integration only within the frame-work of a common European market for all products and services.[9]

The strongest and most consistent advocate of agricultural integration in Europe, the Dutch Minister of Agriculture, S. L. Mansholt, has more recently also come to emphasize the inadequacy of the "sector approach," and that agricultural union must be part of a general economic union. He believes that progress in the agricultural field is mainly dependent on the

[7] The common list comprises the products that are completely freed from quantitative restrictions, in intra-European trade, by all countries alike. (Exceptions are permissive only for countries in acute payments difficulties, by special consent of the OEEC.) For a discussion of European trade liberalization under OEEC see the article by Elfriede Krause in *Foreign Agriculture*, Vol. XVI, No. 5, May 1952.

[8] Loc. cit., p. 111ff., especially p. 154.

[9] "... il est important que la formation du marché commun concerne simultanément tous les produits agricoles et les autres produits de l'activité économique." Publication No. 12: *L'Agriculture dans la Formation du Marché Commun Européen* (June 1952) published by the Ligue.

further development of the political community in Europe. This is a significant change, since Mansholt at one time pressed ahead with the strictly agricultural scheme.[10] And it is an impressive example of subtle coordination among government departments that the Netherlands again assumed leadership in the drafting of a Constitution for a European political Community. Such a draft was prepared by representatives of the political parties of the six Coal and Steel Pool countries;[11] It includes the basic principle of a common market. The draft Constitution is now under consideration by the Governments.

Conclusion

In countries outside Europe as well, European integration cannot be judged on economic grounds alone. It must be judged from the viewpoint of general policy, though economic considerations will play a part. Thus the attitude of the United States government—consistently supporting international cooperation and European efforts at political and economic unification—has been benevolent toward plans for a broader integration of the European market, including agricultural as well as other commodities. At the same time, the United States served notice that such plans must not only mean progressive elimination of trade barriers among European countries, but must also aim at lowering barriers of trade with the rest of the world.[12]

On the economic point it is well to keep in mind that because of the difficulties that have been mentioned, there is always a danger that the movement might degenerate into something akin to an intra-European cartel with long-term purchasing contracts among its members. In any case the scheme would, for overseas products, certainly mean greater competition in European markets either as a result of greater European protection, or as a result of greater European productivity, and in any case as a result of the elimination of intra-European barriers. In connection with the direct effects of such integration upon U. S. export markets it should also be noted that all plans for increases in productivity and production and larger intra-European trade are, in part at least, focused on the balance of payments problem, specifically with respect to the dollar area. Only over the long pull would European integration, in raising productivity and standards of living and through better utilization of resources, stimulate the international division of labor and hence world trade.

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[10] See also S. L. Mansholt. "Toward European Integration: Beginnings in Agriculture," in: *Foreign Affairs*, Vol. 31, No. 1, October 1952.

[11] France, Germany, Belgium, Luxembourg, Netherlands, Italy.

[12] Cf. MSA press release, Washington, D.C. and Paris, France, March 23, 1952.

ALTERNATIVE FUNCTIONS FOR ANALYZING A FERTILIZER-YIELD RELATIONSHIP*

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Introduction

THE objective of this particular analysis is to derive from given experimental data the parameters of physical production functions and, with these derived functions and particular price relationships, to determine what rates of fertilization would yield maximum net revenue for the corn production enterprise.

The data used are the results of a series of corn fertility experiments conducted in the Coastal Plain of North Carolina by the North Carolina State College Department of Agronomy in cooperation with the Bureau of Plant Industry, Soil and Agricultural Engineering of the U. S. Department of Agriculture.[1] The moisture conditions under which these experiments were carried out were classified into "good" and "dry."[2]

The analysis is divided into three parts:

1. Selection of a function. Here consideration is given to the problems involved in choosing particular mathematical functions to represent the relationships under study. Functions are sought to represent the relationships both between yield and a single fertilizer input and between yield and several fertilizer inputs. Consideration is given to the nature of the relationship between yield and input under both "dry weather" and "good weather" conditions.
2. Fitting the functions for a single input.
3. Using the fitted functions and selected price data to ascertain optimum fertilization rates.

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[1] A summary of these experiments and results is found in B. A. Krantz, *Fertilize Corn for Higher Yields,* Bulletin 366, Agri. Exp. Sta., N. C. State College, Raleigh, 1946.

[2] The terms used to describe weather conditions are defined as follows:
"Dry"—during the five-week critical period the soil moisture was low enough to cause leaves to roll for one week or more. "Good"—the rainfall distribution was about normal and soil moisture conditions were not low enough to cause the leaves to roll during this period. For further discussion of weather effects, see Krantz, *op. cit.*, pp. 11-12, 38-41.

Selecting a Function

In order to determine corn yield as a function of pounds of nitrogen, three types of prediction equations were considered.

The power function,[3] $Y = aX^b$, has been tried, although it does not appear to be in accord with the logic of the relationship. If $b > o$, this equation implies a continually increasing yield reaching neither a maximum nor a limiting yield, and this seems hardly reasonable, particularly in the case of only one input varied.

The second type of equation used was the simple polynomial, $Y = a + bX + cX^2$, with the variables in the same units as for the power function. This curve has the advantage of being the simplest to fit of any of the equations used here. It is a multiple regression with (in effect) two independent variables, X and X^2. No transformation or complex fitting processes are needed. The function has *merit* if all that is desired is an input-output statement for one variable fertilizer element with the other inputs fixed. Among the disadvantages in the use of this relationship is the difficulty of imputing any biological meaning to the squared term.

The third type of equation used was the Mitscherlich Law (an exponential form). This type of function involves non-linear parameters, and this complicates the fitting of the function. As a result, relationships of this sort have not been used to any large extent by other workers. H. O. Hartley has outlined why non-linear regressions have been avoided;[4] his reasons include complication of computational procedures; lack of goodness of fit tests; transformations to linearity involve unknown parameters that must be estimated from the sample; the difficulty of deciding what system fits the problem. These points are relevant and must be kept in mind when the exponential curve is used as the production function.

Two forms of the Mitscherlich Law have been used: The Spillman expression and an expression used by Hartley. The first is the form, $Y = M - AR^X$, where Y is bushels per acre, M is a theoretical maximum, A is the difference between Y at $X = O$ and Y at M, R is a geometric ratio between successive increments of Y ($R < 1$), and X is the input value in twenty-pound units of nitrogen. The second form is $Y = \hat{Y}(1 - Ce^{KX})$, where $\hat{Y}$ is a limiting response, C is a constant, e is the base of natural logarithms, K is a constant, and X is the input value. Both of these functions approach an asymptote ($Y = M$ and $Y = \hat{Y}$, respectively). Both involve unknown parameters that must be approximated from the sample.

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[3] Y is the yield of corn in bushels, X is the input of nitrogen in twenty-pound units, and a and b are parameters.

[4] H. O. Hartley, "The Estimation of Non-Linear Parameters by Internal Least Squares," *Biometrica*, 1948, Vol. XXXV, pp. 32-45.

Standard errors or statistical tests of significance cannot be found for the parameters computed in these exponential forms.

Much of the work on plant growth does assume an asymptotic growth curve. However, in the absence of overpowering reasons from biological logic for using some other curve, the polynomial may be the choice for certain purposes because of its simplicity and ease of computation.[5]

Little empirical work has been done on the selection of functions for more than one input variable for plant production. Selection depends on the manner in which certain inputs combine. In the fertilizer problem

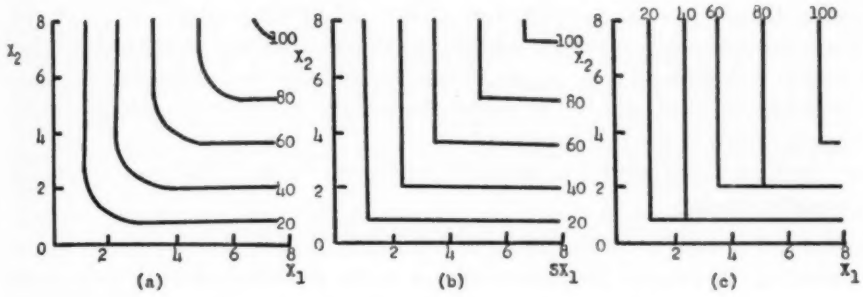

FIG. I. ILLUSTRATIONS OF POSSIBLE HYPOTHESES FOR THE WAY IN WHICH FERTILIZER INPUTS COMBINE IN PLANT GROWTH

under consideration, this involves the characteristics of the various plant nutrients in combination. Fundamental biological knowledge of the manner in which the nutrients combine apparently has not yet been completely worked out. The correct mathematical statement of the production function can be ascertained only when the physical and biological aspects of the problem are agreed upon.

In the absence of an accepted explanation of the manner in which plant nutrients combine in their effects upon yields, several hypotheses may be advanced. It is possible that the various nutrients may be substituted for one another at some rate (see Figure Ia).[6] This is the familiar isoquant field. Within narrow ranges, the same amount of product may be obtained from several combinations of two nutrients. Further information is badly needed on the ranges within which physical substitution is possible and the rates of substitution within these ranges.

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[5] See W. L. Stevens, "Asymptotic Regression," *Biometrics*, Sept. 1951, VII: 247-267.

[6] For purposes of simplicity, the illustrations show only *two* nutrients in combination. It seems clear that at least three nutrients, nitrogen, phosphoric acid, and potash, must be considered for corn production.

A second hypothesis might be that of fixed proportions (see Figure 1b). Here any specified amount of product can be obtained best[7] from one combination of the two nutrients; additional amounts of one nutrient alone will not increase output at all. Thus the two nutrients are not substitutable over any range. This hypothesis should not be ignored in the case of the fertilizer-yield function; it is possible that the plant growth is the familiar textbook example of chemical phenomena in fixed proportions.

A third hypothesis has been suggested[8] as fitting some empirical data (see Figure 1c). Here some minimum amount of each nutrient is necessary to achieve any production. Then additional applications of one nutrient only will result in additional yields, until the other nutrient becomes a limiting factor again. Then an additional amount of the other nutrient enables additional output to be obtained from each of several applications of the first nutrient.[9]

Spillman extended his function to handle more than one input, the equation being

$$Y = M(1 - R_1^{X_1})(1 - R_2^{X_2})(1 - R_3^{X_3}),$$

where Y, M, R, and X are the same as in the one-variable form except the subscript denotes the nutrient involved. This equation postulates the same rate of response to any one nutrient regardless of the quantity of the other nutrients present. This concept may well be the correct one but it requires more proof from experimental observations, and from biological logic.

The final question in the selection of prediction equations involves the choice for fitting data under "dry" weather conditions. A priori, there appears to be no reason to prefer a different function for adverse weather conditions than for favorable weather. Only a polynomial was fitted to the "dry" weather observations. However, different parameters resulted from different weather conditions.

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[7] Even in the physical sense.

[8] By scientists conducting research in plant science.

[9] Such a configuration of data might arise due only to inability to make precise measurements of inputs. For example the nitrogen, phosphoric acid, and potash drawn by a plant from the soil may have been placed there (a) as fertilizer just before the seeds (or plants) were placed in the soil, (b) during some stage of growth, or (c) these nutrients may have been in the soil at the time the starter fertilizer was applied. Imperfect knowledge of the plant nutrients available may have resulted in an "unbalanced" application of additional nutrients; thus application in an adjacent plot of an additional amount of one nutrient may have resulted in additional output that actually should be attributed not only to the additional application but also to hitherto unused quantities of the other nutrients. This could be consistent with the second hypothesis being the correct one, or might be consistent with the first, if the range of substitution were rather restricted.

Fitting the Functions for a Single Input

In a partial analysis when the quantity of only one input is varied by control methods, the other variables may be handled in one of two ways: (1) by holding the other variables constant at a fixed level; or (2) by allowing the other variables to vary, assuming their variation to be random in their effect upon the variable under observation. In a study of the relationship of corn yield to nitrogen applications, a large number of other inputs such as phosphorus, potash, soil type, weather, seed variety, number of plants, and a host of other factors has a bearing on yield.[10] In the experimental data used here: the seed variety was the same; phosphorus and potash applications were held constant at an "adequate" level; soil types were judged quite similar; number of plants was a function of the pounds of nitrogen, although there was variation in plant population for each application of nitrogen;[11] observations were separated into two categories according to the moisture conditions; time of application was controlled in order to use that as an independent variable; all other variables were assumed to vary in a random manner.[12] The variability inherent in biological data makes this procedure about the best that can be done presently. The results of experimentation cannot be generalized too far from the conditions that generated them, but an "average" function of this sort is applicable to a larger area than if the results were restricted to one set of experimental conditions.[13]

For the functions fitted here "good" weather observations at twenty-pound intervals of nitrogen were averaged for twenty-nine experiments in the Coastal Plain. The observations ranged from 0 to 180 pounds of nitrogen, and were confined to relatively similar soil types.

The fitted power function[14] was:

$$Y = 26.34\,(X + 1)^{0.59} \text{ and } \frac{dY}{dX} = 15.54\,(X + 1)^{-0.41}$$

The heavy line in Figure II-A shows the function itself while the first derivative (rate of change) is shown as a broken line. The points are the actual observations.

[10] Here we are dealing only with the quantitative aspect of yield; while it is recognized that many, if not all, practices affect quality of corn, this effect is here ignored. For one aspect of quality relationships, see Krantz, *op. cit.*, pp. 18-19.

[11] Rigorous economic analysis would require that the cost of heavier applications of seed be considered; for the purposes of this paper, this question was ignored.

[12] For a more elaborate description of the experimental conditions, see Krantz, *op. cit.*, pp. 9-34.

[13] See E. M. Growther and F. Yates, "Fertilizer Policy in War Time," *Empire Journal of Experimental Agriculture*, April 1941, IX, No. 34: 77-97.

[14] The independent variable has been arbitrarily increased by one to $(X + 1)$, because no logarithm exists for 0 where $X = 0$.

The polynomial became:

$$Y = 25.16 + 15.19X - 0.836X^2 \text{ and } \frac{dY}{dX} = 15.19 - 1.67X$$

The function and its derivative in relation to the actual observations are shown in Figure II-B. This equation covers a range of from 25 bushels per acre at no nitrogen to 94 bushels at 180 pounds.

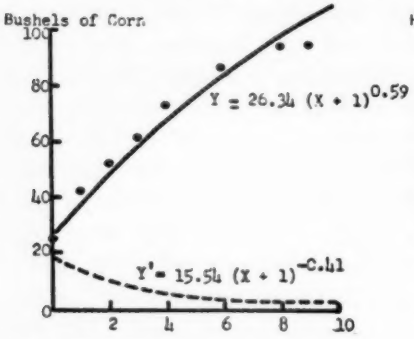

FIG. II-A. TWENTY-POUND UNITS OF NITROGEN

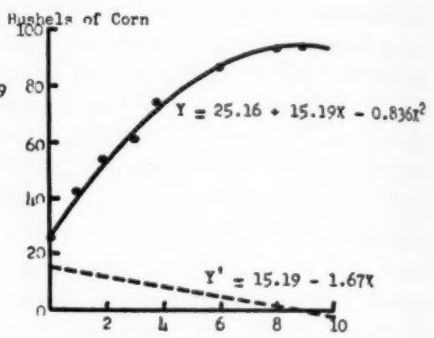

FIG. II-B. TWENTY-POUND UNITS OF NITROGEN

For the fitting of the first of the exponentials, the Spillman form, Mendum[15] has devised a short-cut approximation. Using an iterative technique and least squares gave the equations, $Y = 108 - 82.484\ (0.8133)^X$ and $\frac{dY}{dX} = -82.484\ (\log_e 0.8133)\ (0.8133)^X = 17.077\ (0.8133)^X$.

The graphs of these equations are shown in Figure III-A.

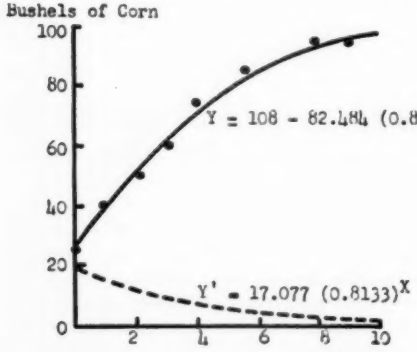

FIG. III-A. TWENTY-POUND UNITS OF NITROGEN

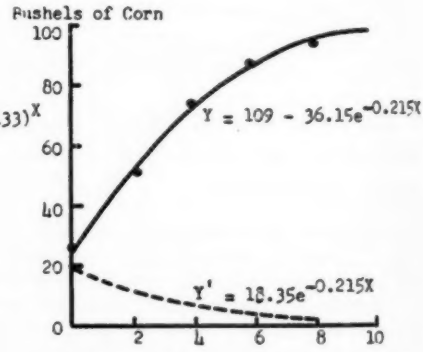

FIG. III-B. TWENTY-POUND UNITS OF NITROGEN

Y is in bushels of corn, and X is in twenty-pound units of nitrogen in the three forms shown above.

[15] S. W. Mendum, "A Device for Analyzing Yields," *This Journal*, May 1948. XXX: 357-364.

Hartley has devised an exact fitting procedure for the second form of the exponential.[16] The solution is based on linear coefficients of an equation in Y and the successive sums of X. These coefficients are used to determine the non-linear parameters of the original equation. The fitted function of this form was $Y = 109 - 36.15\ e^{-0.43Z}$ and

$$\frac{dY}{dZ} = -36.15\ (-0.43)\ e^{-0.43Z} = 15.54\ e^{-0.43Z},$$

where Z is a coded X value.[17] This function requires equally spaced X values. This meant using forty pound increments of nitrogen because output data were missing for 100 and 140 pounds of nitrogen. The sensitivity of the curve was thus reduced for the higher values of X. The graph of the equation and its first derivative can be seen in Figure III-B.

A polynominal was fitted to the "dry" weather observations—observations that went only to 120 pounds of nitrogen. The equation was

$$Y = 15.4 + 13.8X - 1.16X^2 \text{ and the slope, } \frac{dY}{dX} = 13.8 - 2.32X.$$

The equation and its slope are shown in Figure IV.

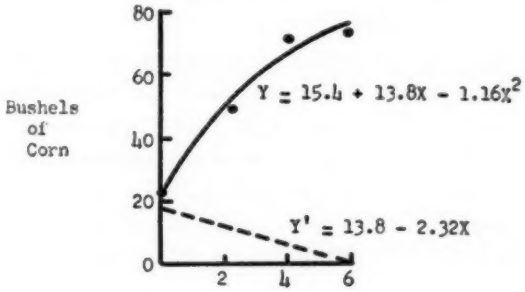

FIG. IV. TWENTY-POUND UNITS OF NITROGEN

Thus not only did the position of the curve change, from the "good" to "dry" observations, but the slopes were different, implying that the input was being transformed into output not only at a different level but also at a different rate.

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[16] H. O. Hartley, "The Estimation of Non-Linear Parameters by Internal Least Squares," *Biometrika*, 1948, XXXV: 32-45.

[17] In terms of X expressed in terms of twenty-pound units of nitrogen, $Z = \frac{X-4}{2}$, and $Y = 109 - 85.53\ e^{-0.21X}$, $\frac{dY}{dX} = 18.35\ e^{-0.21x}$

Application of the Prediction Equations

To determine the optimum amount of a plant nutrient to use, it is necessary to use the least expensive source of that nutrient.[18] There are important differences in the price of the sources of nitrogen.[19] At present, the cheapest source of nitrogen to the majority of farmers is ammonium nitrate although liquid nitrogen is cheaper when available.[20] The prices used here are the April 1951 price of ammonium nitrate, and the 1951 average price received by North Carolina farmers for corn sold. Thus, P_X (for 20 pounds of nitrogen) = \$2.74, P_Y (for a bushel of corn) = \$1.75.

TABLE 1. OPTIMUM APPLICATION OF NITROGEN TO USE PER ACRE OF CORN, DETERMINED BY USING DIFFERENT PREDICTION EQUATIONS AND 1951 PRICES FOR CORN AND NITROGEN

Type of Equation	$\frac{dY}{dX}$	Optimum Application	
		in 20-lb. Units	in lbs.
Power Function	$15.54\,(X+1)^{-0.41}$	267.0	5340
"Good" Weather Polynomial	$15.19-1.67X$	8.2	164
Spillman Exponential	$17.077\,(0.8133)^{X}$	11.5	230
Hartley Exponential	$18.35e^{-0.216X}$	11.4	228
"Dry" Weather Polynomial	$13.8-2.32X$	5.3	106

In production planning, of course, expected prices would be used.

Under the assumptions used here, there are several means by which most profitable application of nitrogen can be determined. In general, the farmer with a cash corn enterprise would maximize profits (or minimize losses) for that enterprise by producing at the output where (a rising) marginal cost equals marginal revenue (price), or in other words, the point just before which further output would add more to total cost than to total receipts.

If the relationship between yield and input is a continuous function and is known, the solution can be made more exact. The first derivative of the equation is the rate at which the input is transformed into product. It will pay any farmer to produce to the point where this transformation rate is equal to the price ratio of the input and output. This price ratio

[18] Assuming that all sources are homogeneous with respect to corn growth; there is evidence to indicate, however, that this assumption is not entirely valid.

[19] The prices used in this study were the purchase prices of nitrogen at the purchase point; to be perfectly realistic the costs of handling and application should be incorporated in the price used. For the purpose of this study, these costs are believed not to involve important differences.

[20] Two forms of liquid nitrogen are presently being used experimentally, and commercially on some large farms. For a more complete discussion of nitrogen sources, see S. L. Tisdale et al., *Sources of Nitrogen in Crop Production*, Technical Bulletin No. 96, N. C. Agricultural Experiment Station, Raleigh, December, 1952.

is the slope of a straight line, which will be equal to the slope of the equation (rate of transformation) at some point of tangency. This point can be found by setting the first derivative of the production function

TABLE 2. EFFECT OF DIFFERENT PRICES FOR NITROGEN AND CORN, AND THE USE OF DIFFERENT PREDICTION EQUATIONS ON MOST PROFITABLE QUANTITY OF NITROGEN TO USE IN PRODUCING CORN IN THE COASTAL PLAIN OF NORTH CAROLINA

Type of Function	Price of Corn Per Bu.	Source of Nitrogen		
		Liquid Nitrogen[a]	Ammonium Nitrate	Nitrate of Soda[a]
		(Price per Pound)[b]		
		$0.10[c]	$0.137[d]	$0.191[d]
	(Dollars)	(Pounds of Nitrogen)		
"Good" Weather Polynomial	1.75[e]	168	164	156
	1.30[f]	164	156	146
	1.00[e]	158	150	136
	0.75[e]	150	138	120
Spillman Exponential	1.75[e]	262	230	200
	1.30[f]	232	202	170
	1.00[e]	208	178	144
	0.75[e]	180	150	118
Hartley Exponential	1.75[e]	258	228	198
	1.30[f]	230	202	170
	1.00[e]	206	176	146
	0.75[e]	180	150	120
"Dry" Weather Polynomial	1.75[e]	110	106	100
	1.30[f]	106	100	94
	1.00[e]	102	96	86
	0.75[e]	96	88	76

[a] Assuming that the production coefficients for liquid nitrogen and nitrate of soda are the same as for ammonium nitrate. See footnote 18.

[b] The actual prices of nitrogen fertilizers used in this study were the purchase prices at the purchase point; to be more realistic the costs of handling and application should be incorporated in the price used.

[c] Hypothetical price.

[d] April, 1951 price.

[e] Average price of corn received by North Carolina farmers in 1951.

[f] Average price of corn received by North Carolina farmers in 1949.

equal to the slope of the linear price relationship and solving for the input value that satisfies the equation.[21]

Thus with a price for nitrogen of $2.74 per 20 pound unit and a price for corn of $1.75 per bushel, we find the price ratio $\frac{P_X}{P_Y} = \frac{\$2.74}{1.75} = 1.57$. Taking the first derivatives of the prediction equations and equating them

[21] If the production function is $Y = a + bX + cX^2$, $dY/dX = b + 2cX$. In perfect competition the producer equates $(\Delta Y)(Py)$ to $(\Delta X)(P_X)$. In the continuous function this is approximately equal to $(b + 2cX)(P_Y) = (P_X)$ or $dY/dX = \frac{P_X}{P_Y}$.

TABLE 3. RELATIONSHIPS BETWEEN QUANTITY OF NITROGEN APPLIED AND CORN YIELD: OBSERVED YIELD AND YIELD COMPUTED BY MEANS OF DIFFERENT PREDICTION EQUATIONS

Nitrogen per Acre	Corn Yields Per Acre				
	Observed Yield	Computed Yields			
		"Good" Weather Polynomial	Power Function	Exponential: Spillman Form	Exponential: Hartley Form
(pounds)	(bushels)	(bushels)			
0	24.5	25.2	26.3	25.5	23.5
20	41.5	39.5	39.6	40.9	40.0
40	52.1	52.2	50.4	53.4	53.4
60	61.4	63.2	59.7	63.6	64.1
80	73.5	72.5	68.1	71.9	72.8
100	[a]	80.2	75.8	78.6	79.8
120	86.0	86.2	83.0	84.1	85.5
140	[a]	90.5	89.8	88.6	90.0
160	92.8	93.2	96.3	92.2	93.7
180	94.0	94.2	102.5	95.2	96.6
200	[a]	93.5	108.5	97.6	99.0

[a] Not available.

to the price ratio, we obtain the results shown in Table 1. These computations tell us that if the particular equation represented the true relationship that it would be economical to apply 5340, 164, 230, 228, or 106 pounds of nitrogen per acre, respectively.

Table 2 shows the effects of using the 1949 price of corn, the 1951 price of corn, hypothetical prices for corn, the price per pound of nitrogen in ammonium nitrate and in nitrate of soda, and an assumed price for liquid nitrogen on the optimum quantity of nitrogen as given by these different functions.

Conclusions

Table 3 compares the observed yields of corn[22] with the yields computed by using the different prediction equations. It can be seen readily that the polynomial fits the actual observations much more closely in the range studied in the basic experiments. The power function seems to be a very poor fit, especially in the very important upper range. For the observations used, the Spillman form of the exponential appears to be slightly closer fit than the Hartley form. For purposes of interpolation the polynomial apparently would give the best results, but would appear to be least suitable for extrapolation. If it were necessary to make an extrapolation, the Spillman exponential would a priori probably be less dangerous.

[22] Under "Good" weather conditions.

The two exponentials probably are more in accord with biological logic, as we know it today. The power function appears to be contrary to such logic, and the polynomial bears little relation to such logic.[23]

This analysis begs the aggregative question of what the most profitable position would be for an individual producer if all corn producers should use what appears to be optimum quantities of the different nutrients. It fails to consider the consequences of producer behavior in terms of factor and product prices. It does show how profitable positions could be determined for individual firms under specified price and weather conditions. In planning production the probability of occurrence of each of the weather functions must be known for "optimum choice" among these.

[23] Except that any continuous function can be expanded by means of a Taylor expansion into a polynomial whose values will differ from these of the actual function by less than any chosen quantity. Thus it would appear permissible to utilize the polynomial until we ascertain from biological logic what the form of the actual function should be.

MINIMIZING GRAIN STORAGE COSTS*

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THE study of grain storage costs is important for two reasons. First, these costs determine the feasibility of grain carryover programs, representing a disadvantage which must be weighed against the gains arising from such programs. This first reason implies finding the cost magnitudes associated with various storage programs, and to do this with sufficient accuracy may well not require serious attention to alternative ways of making decisions necessary in the handling of stocks. The second reason for the importance of storage costs is that they result from a set of economic decisions the efficiency of which, like that of any other economic decisions, it is the legitimate task of research to further. Ways of minimizing the costs of storage have received little attention heretofore. Perhaps this is due to the fact that even with large scale government operations, the handling of stocks has been to a large extent left to the market mechanism. Nevertheless, the government does often control a great deal of grain in connection with price support arrangements, involving long term storage not ordinarily undertaken by the free market. Besides minimizing the costs of its own activities, the government, in the public interest, needs to conduct storage operations which affect market decisions so as to facilitate the functioning of the private sector of the economy. Further, knowledge of the conditions under which storage costs will be minimized provides a means for gauging the efficiency of decisions made by the market.

Storage costs are considered in the present paper in relation to the second of the two reasons which have been noted. Methods will be discussed (1) for deciding where to locate stocks geographically, (2) for choosing between alternative types of storage facilities, and (3) for determining stock replacement policy. In each, the decisions are discussed under simplifying assumptions which permit consideration of important principles in these decisions, and extensions are alluded to but not dealt with fully which would make the examples more realistic and hence more readily applicable to concrete problems.

* This paper is based in part on research conducted under a contract between the University of Chicago and the Bureau of Agricultural Economics financed from funds authorized under the Research and Marketing Act of 1946. I wish to emphasize my debt to Professor Hildreth, who solved the problem on type of facilities, although, of course, responsibility for any shortcomings of the paper is entirely mine. Almost no literature has been cited because there is little which is directly relevant; a main motivation in this paper was the belief that one barrier to better stock management decisions is the lack of criteria for making these decisions, but I wish in no way to slight the excellent work which has been done in grain storage economics.

Scope of Paper

It is perhaps advisable, before beginning, to emphasize the intended scope of the paper. As has been pointed out, the examples to be considered are highly simplified. There are, further, many kinds of decisions other than those considered here relevant to minimizing storage costs. Thus, to cite only three, attention is needed to such problems as arise in the competition of different kinds of grains for the use of facilities, the competition of within-year and carryover storage for the use of facilities, and optimal methods of alleviating transport gluts at harvest time. For these reasons, the analysis is clearly not suited to wooden application of the procedures which emerge. What contribution, then, can this paper claim to make? In spite of their shortcomings, I believe the examples are useful in providing a basis for achieving efficient procedures in the following ways:

First, they may be integrated and complicated, including explicit introduction of probabilities in dealing with the future, a task not attempted in this paper.[1] Although not needed with a small number of variables, linear programming techniques lend themselves readily to these cost minimizing problems and may be of great aid in obtaining numerical estimates with respect to the different decisions simultaneously. *Second,* while the simplifications made necessarily restrict the direct applicability of the examples, they point out the logic that needs to be used when storage decisions are arrived at, as they always are in practice, by less formal methods. From this point of view, the simplifications are an advantage rather than a disadvantage. *Third,* guides are given to the collection of storage cost data. Knowledge about storage costs is quite fragmentary. In the accumulation of this information, attention is needed on the conditions of least cost storage which are illustrated. One important instance is in choosing between types of facilities. Here, rather than the total cost of storage per bushel, costs incurred for different time horizons need to be carefully distinguished. Another instance is the manner in which grain deteriorates, which remains in doubt although it determines stock replacement policy and would appear to be quite susceptible of empirical determination. *Finally,* a basis is provided for evaluating and improving performance in storage functions. The reasoning below is as if decisions were made by a central agency. As such they may be more immediately applicable to CCC operations. However, insofar as decisions are decentralized, further problems involving institutional relationships must be faced. As

[1] Seymour Smidt, in further research financed from funds authorized under the Research and Marketing Act of 1946, has developed models where future values of variables are not known with certainty, as part of a larger empirical study of the management of carryover stocks.

TABLE 1. GRAIN STORAGE IN A LOCALITY GIVEN TOTAL STORAGE AND ONE ALTERNATIVE LOCATION

(Production and use refer to locality in question)

I. If current production exceeds current use by more than the total amount of storage
  a. and future production exceeds future use
    (i) and storage cost is less than alternative storage cost plus transport cost minus discounted future transport cost: STORE ALL GRAIN HERE.
    (ii) and storage cost is more than alternative storage cost plus transport cost minus discounted future transport cost: STORE NO GRAIN HERE.
  b. and future use exceeds future production, but by less than the total amount of storage
    (i) and storage cost is less than alternative storage cost plus transport cost minus discounted future transport cost: STORE ALL GRAIN HERE.
    (ii) and storage cost is more than alternative storage cost plus transport cost minus discounted future transport cost, but less than alternative storage cost plus transport cost plus discounted future transport cost: STORE EXCESS OF FUTURE USE OVER FUTURE PRODUCTION HERE.
    (iii) and storage cost is more than alternative storage cost plus transport cost plus discounted future transport cost: STORE NO GRAIN HERE.
  c. and future use exceeds future production by more than the total amount of storage
    (i) and storage cost is less than alternative storage cost plus transport cost plus discounted future transport cost: STORE ALL GRAIN HERE.
    (ii) and storage cost is greater than alternative storage cost plus transport cost plus discounted future transport cost: STORE NO GRAIN HERE.

II. If current production exceeds current use, but by less than the total amount of storage
  a. and future production exceeds future use
    (i) and storage cost is less than alternative storage cost plus transport cost minus discounted future transport cost: STORE ALL GRAIN HERE.
    (ii) and storage cost is more than alternative storage cost plus transport cost minus discounted future transport cost, but less than alternative storage cost minus transport cost minus discounted future transport cost: STORE EXCESS OF CURRENT PRODUCTION OVER CURRENT USE HERE.
    (iii) and storage cost is more than alternative storage cost minus transport cost minus discounted future transport cost: STORE NO GRAIN HERE.
  b. and future use exceeds future production, but by less than the total amount of storage
    1. and combined present and future use exceeds combined present and future production
      (i) and storage cost is less than alternative storage cost minus transport cost minus discounted future transport cost: STORE ALL GRAIN HERE.
      (ii) and storage cost is more than alternative storage cost minus transport cost minus discounted future transport cost, but less than alternative storage cost minus transport cost plus discounted future transport cost: STORE EXCESS OF FUTURE USE OVER FUTURE PRODUCTION HERE.
      (iii) and storage cost is more than alternative storage cost minus transport cost plus discounted future transport cost, but less than alternative storage cost plus transport cost plus discounted future transport cost: STORE EXCESS OF CURRENT PRODUCTION OVER CURRENT USE HERE.
      (iv) and storage cost is more than alternative storage cost plus transport cost plus discounted future transport cost: STORE NO GRAIN HERE.
    2. and combined present and future production exceeds combined present and future use
      (i) and storage cost is less than alternative storage cost minus transport cost minus discounted future transport cost: STORE ALL GRAIN HERE.
      (ii) and storage cost is more than alternative storage cost minus transport cost minus discounted future transport cost, but less than alternative storage cost plus transport cost minus discounted future transport cost: STORE EXCESS OF CURRENT PRODUCTION OVER CURRENT USE HERE.
      (iii) and storage cost is more than alternative storage cost plus transport cost minus discounted future transport cost, but less than alternative storage cost plus transport cost plus discounted future transport cost: STORE EXCESS OF FUTURE USE OVER FUTURE PRODUCTION HERE.
      (iv) and storage cost is more than alternative storage cost plus transport cost plus discounted future transport cost: STORE NO GRAIN HERE.

TABLE 1—(*continued*)

c. and future use exceeds future production by more than the total amount of storage
  (i) and storage cost is less than alternative storage cost minus cost of transport plus discounted future transport cost: STORE ALL GRAIN HERE.
  (ii) and storage cost is more than alternative storage cost minus cost of transport plus discounted future transport cost, but less than alternative storage cost plus transport cost plus discounted future transport cost: STORE EXCESS OF CURRENT PRODUCTION OVER CURRENT USE HERE.
  (iii) and storage cost is more than alternative storage cost plus transport cost plus discounted future transport cost: STORE NO GRAIN HERE.

III. If current use exceeds current production
a. and future production exceeds future use
  (i) and storage cost is less than alternative storage cost minus transport cost minus discounted future transport cost: STORE ALL GRAIN HERE.
  (ii) and storage cost is more than alternative storage cost minus transport cost minus discounted future transport cost: STORE NO GRAIN HERE.
b. and future use exceeds future production, but by less than the total amount of storage
  (i) and storage cost is less than alternative storage cost minus transport cost minus discounted future transport cost: STORE ALL GRAIN HERE.
  (ii) and storage cost is more than alternative storage cost minus transport cost plus discounted future transport cost: STORE NO GRAIN HERE.
c. and future use exceeds future production by more than the total amount of storage
  (i) and storage cost is less than alternative storage cost minus transport cost plus discounted future transport cost: STORE ALL GRAIN HERE
  (ii) and storage cost is more than alternative storage cost minus transport cost plus discounted future transport cost: STORE NO GRAIN HERE.

already noted, considerations as to least cost storage provide a norm in achieving the best possible arrangements for these decisions.

Location of Stocks

In determining where grain stocks can be located at least cost, present and future production and use of grains between localities, costs of storage, costs of transport, and the rate of interest are all interrelated. As an example, suppose that grain is grown and used in two localities, that a decision has been made to store a certain amount of grain in the present time period to be used in a given future time period, and that we wish to decide how much of the grain shall be stored in each locality. The problem can be discussed from the point of view of only one locality, since if the amount to be stored in one place is decided, the amount stored in the other is merely the residual.[2]

There are ten possible situations with respect to imports and exports between the localities, and each implies a different rule as to the location of stocks. These are summarized in Table 1. For illustrative purposes, only one case will be discussed. Thus, consider II-b-1, where both localities have an excess of production over use in the present year and an excess of use over production in the future year, with the combined production

[2] In this example, linear cost functions will be assumed so that no distinction is needed between average and marginal cost. Also, no distinction will be made between short and long run costs.

in the first locality for both years greater than its combined use for both years. If the cost of storing in the first locality is sufficiently low in relation to that in the second, all storage will take place in the first locality. If this is done, it must be profitable to ship the present excess of production over use in the second locality to the first and then ship it back in the future year. The cost of this operation is present transport cost between the localities plus discounted future transport cost. For all storage to take place in the first locality, then, its cost of storage must be less than storage cost in the second minus the cost of shipping in both the present and future year (II-b-1-i in the table). Similarly, if the cost of storing in the first locality exceeds cost in the second by more than the cost of shipping in both years, all storage will take place in the second locality (II-b-1-iv). If the difference in storage costs in the two localities falls between the limits of these two cases, "back-hauling" of grain is unprofitable, and some grain will be stored in each locality. The question becomes whether the first locality should make its export to the second locality in the present or the future year. If grain is to be shipped in the present year, undiscounted rather than discounted transport costs will be incurred. The cost of storing in the second locality must fall below cost in the first by more than the difference between present and future transport cost (II-b-1-iii). If it does not, the export will take place in the future year (II-b-1-ii).

It is hoped that this illustration is sufficient to suggest how the additional cases are derived. The conclusions presented in Table 1 should not, of course, be taken as prescriptions for storing, for it is difficult to think of any practical problem where the assumptions underlying it would be the only relevant ones. Extension of the analysis might consist in considering (1) more than two time periods, (2) more than two localities, and (3) optimal decisions where future variables are not known with certainty. Two-period analysis may be suitable when considering storage of a given amount of grain for defense, when grain is to be stored now and used at some later date when a war contingency occurs. Even here, however, the problem of building up stocks is ignored as is uncertainty as to the date of the contingency and the problem of how the stocks will be used if the contingency does not arise. If one is considering storage programs which depend on yield and demand variation, either with or without a defense program, stocks will move in and out of storage over several time periods, and multi-period analysis would be called for. Extension to more than two localities seems called for in any case, since it is especially difficult to picture a real situation where less than three points are involved. The two locality analysis will apply in more complicated cases, however, since these must ultimately reduce to situations where two localities compete for storage.

With respect to decisions when future variables are not known with certainty, one possibility is to consider all variables to have probability distributions, taking the expected values of variables and proceeding as if these values would occur with certainty. Such a procedure, however, may lead to large additional costs when expected values of the variables do not materialize. Suppose, for instance, that a locality is an exporter in the present year and that assuming expected production and use will be an exporter in the future year and that it is slightly cheaper to store in the second locality. (This is case I-a-ii in the table.) If, because of unpredictable variation, the locality turns out to be an importer in the future year, an amount of grain equal to total storage will have been shipped to the second locality in the first period which will now have to be shipped back again. It would therefore seem worthwhile to devote attention to procedures which take account of attributes of future values of variables in addition to expected values.

Type of Facilities

If both the unit fixed costs and the unit variable costs of storing in one type of facility are less than those of any other type, that type of facility will be used exclusively, if storage is to be at least cost. Also, if facilities are used to capacity for their entire life, only one type of facility will be used, namely the one whose fixed cost plus variable cost when used to capacity is less than any other. In other cases, it may be profitable to build both types of facilities, and the decision must be made how much of each type to build.

The following example, whose solution is due to Hildreth, illustrates how such a decision could be made. Assume that there are two types of storage facilities, one where the cost of building and maintaining a unit amount of storage capacity is greater than with the other and where the variable cost of a unit of storage is less than with the other. For convenience, call the first type "elevator" and the second type, "bin." Assume further that the amounts of storage to be undertaken in future years are known. Finally, assume that the following information, which is relevant to the solution, is known: the cost per bushel of building and maintaining capacity of each type of facility, the variable cost per bushel of storing in each type of facility, and the rate of interest. The cost of storing associated with each type of facility will be the cost of capacity necessary to handle the maximum amount stored in that type of facility plus the sum of the discounted variable costs which will be incurred in the use of that type of facility. The sum of these costs for both types of facilities is then the total cost of storage, and the problem is to choose the amounts of storage in each type of facility in each year so as to minimize this cost. Reflection reveals that the solution is contingent only on the amount of

capacity that will be built of each type of facility, since with given amounts of capacity as much as possible will be stored each year in the type of facility with the lower variable cost, that is, in "elevators." Further, since if the capacity in one type of facility is determined the capacity in the other type must automatically be enough to handle storage in the peak year (it cannot be less if all storage is to be accommodated, and it would be uneconomical to build more), the problem reduces to the choosing of capacity of one type of facility.

The method of solution is then to contemplate how total storage costs will vary with differing amounts of capacity of one type of facility. Although as noted, either type could be chosen, "elevator" capacity will be discussed here. The other important element to the solution is the ordering from lowest to highest of the amounts of storage to be undertaken. This ordering, of course, need not and generally would not have any necessary connection with *when* the storage took place. That is, maximum (or minimum or any particular size) storage might occur in the near or far future. "Elevator" capacity could conceivably be between zero and the total amount of storage undertaken in the year of maximum storage. Let us start from zero and find the effects on cost of increasing "elevator" capacity. Up to the point of the minimum amount of storage to be undertaken, when this type of capacity is expanded by one bushel, there will be an increase in fixed costs of the difference between the cost of "elevator" and "bin" capacity and a decrease in variable costs in each year of the difference between variable cost in each type of facility, the latter since the expansion of "elevator" capacity will enable that much more "elevator" as opposed to "bin" storage each year. Thus, if the difference in fixed costs is less than the sum of the discounted difference in variable cost over every year, a decrease in total cost will be obtained by expanding "elevator" capacity, and the conclusion is reached that this type of capacity should be at least equal to the minimum amount of storage. If the difference in fixed costs is more than the sum of the discounted difference in variable costs, no "elevator" capacity will be built, all storage taking place in "bins."

Consider next the effects of increasing "elevator" capacity in the range between the smallest amount of storage and the next smallest amount. As before, there will be an increase in fixed cost of the difference between fixed cost of the two types of facilities. But the decrease in variable cost is not equal to the sum of the discounted difference between variable costs over every year. This is because in the year of smallest storage all storage will already take place in "elevators" and any further increase in "elevator" capacity will hence not change the variable cost in that year. An increase in "elevator" capacity will thus decrease total cost when the difference in fixed costs is less than the sum of the discounted difference

in variable costs over every year except the year of smallest storage. The gain in this range, then, is less than in the previous range, the extent of the difference in gain depending on whether the year of smallest storage is in the far or near future and hence more or less heavily discounted.

It can be seen that as further increases in "elevator" capacity are contemplated, an expansion will decrease total storage cost when the difference in fixed costs is less than the sum of the discounted difference in variable costs for each year except those where the amount of storage is less than the contemplated capacity. We thus arrive at a total cost curve "kinked" at each future amount of storage. If this curve continues to slope downward, that is, if there continue to be positive gains from expanding "elevator" capacity up to the largest amount of storage, only this type of capacity will be built. Since, however, the gain in each range becomes successively smaller, the curve may eventually turn upward, that is, the gain may become negative. The amount of storage in a particular year which is not the maximum amount will then be the point of minimum total cost, and "elevator" capacity corresponding to that amount will be built. A solution is illustrated in Figure 1 for a hypothetical four-period case where the optimum amount of "elevator" capacity is equal to the next to the largest amount of storage.

The recent study of Oklahoma cash grain storage recommends that "regular elevator storage capacity should not exceed the space needed for the expected average quantities to be stored over a long period of years."[3] The technique just outlined provides a way of arriving at an independent estimate of needed elevator capacity. The analysis, here, however, could be extended in three ways to make it more useful empirically. First, it has been assumed that the length of life of the facilities was greater than the total period of time being considered. This may not always be true, and length of life might be introduced into the problem. Second, there may be more than two alternative types of storage facilities to choose among. Third, it has been assumed that future amounts of storage were known. This is seldom so and the problem of making the best decision when future amounts are not known with certainty needs to be considered.

Stock Turnover

An important distinction is between within-year storage and the carry-over of grain from year to year. While this distinction was not crucial in the above analysis, differences between the two kinds of storage arise both as to decisions required and as to computation of costs. One of the

[3] Hail, Larson, Whitney and Myer, *Where and How Much Cash Grain Storage for Oklahoma Farmers*, Farm Credit Administration, USDA, Washington, D.C., May, 1950, page 42.

problems connected with carrying stocks for a number of years is that of providing for replacement of stocks. The consumption of old stocks and their replacement with more recently grown grain may be necessary due to the deterioration of stored grain through time. Figure 2 illustrates different possible ways in which losses may be associated with aging of stocks. Each diagram shows the amount of undeteriorated grain at any given time after initially putting one bushel of grain into storage. In (a), the loss is a constant percentage of the undeteriorated stocks, say 10%

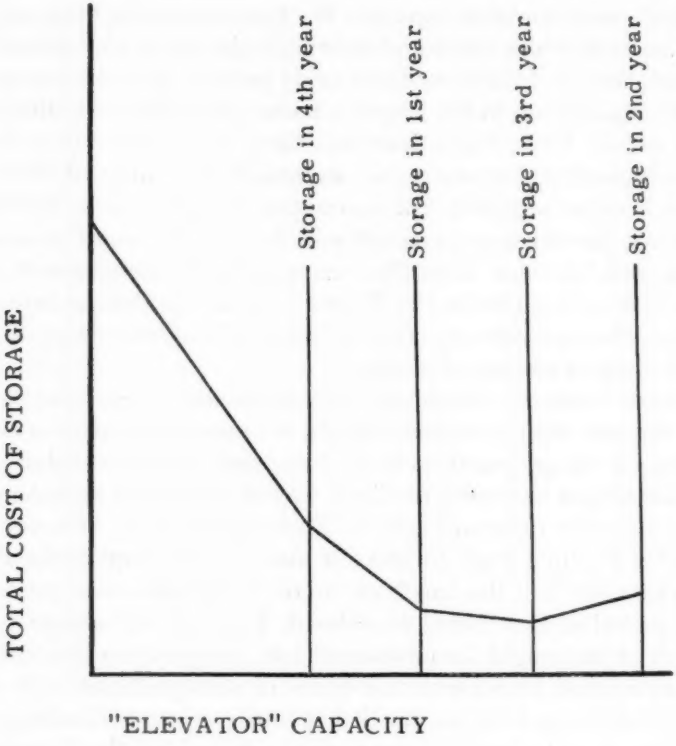

FIG. 1

per year. As will be seen below, if losses are of this form, there may be little replacement problem. In (b), a situation is shown where losses increase precipitously after a certain number of years. In (c), losses are a constant absolute amount per unit of time. The shape of this deterioration function needs to be known in assessing the importance of replacement, although information has not yet been found which would permit a good estimate of it. Some sources say that grain can be stored "indefinitely," but it is not clear what this means in terms of deterioration.

Given some function such as has been depicted, it is possible to find (1) the least amount of grain which must be stored now in order that one bushel will be available in some given year in the future, (2) the replacement policy which will yield least cost storage, and (3) the cost of this storage. Suppose we wish to make one bushel of grain available at the end of a certain number of years. The cost in any year except the first or the last is the cost of carrying[4] the quantity of grain on hand plus, if the grain is replaced, the cost of taking the old grain out of storage and putting in its place an equivalent amount of new grain. In the first year, an amount of grain must be put in storage such that one undeteriorated bushel remains at the end of the final year, and the cost is cost for carrying the initial amount of grain plus the cost of putting this amount into storage

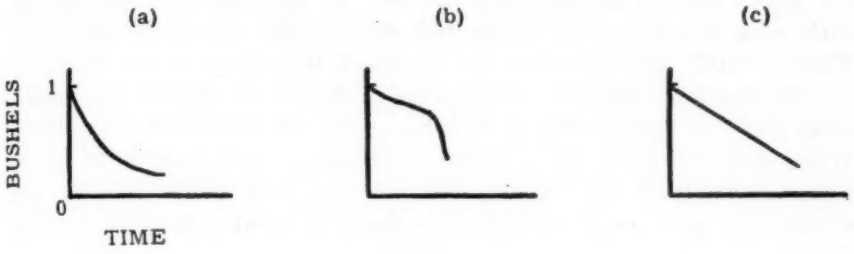

FIG. 2

plus the purchase outlay for the grain. Purchase outlays do not appear in other years because they are exactly offset by the sale of an equivalent amount of old grain. In the last year, costs include charges for taking the final amount of grain out of storage at the end of that year. The cost of storage for the entire period is then the sum of all these costs minus the price received for the grain at the end of the final year.[5]

The minimization of cost involves the choice between how much grain to store initially and how often to replace the grain. If it is replaced often, deterioration losses will be small and a smaller amount of grain will have to be purchased initially. The cost of purchase and the cost of replacement are thus alternatives, and cost minimization requires finding how much of each kind of cost to incur. The solution is provided in considering for each future year the two following expressions:

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[4] "Cost of carrying" in this section is exclusive of deterioration losses.

[5] Perhaps a better procedure would be to subtract price in the initial rather than the final year, considering any price changes as "speculative" gains or losses and enabling them to be distinguished from deterioration losses. Price changes will not be dealt with here.

$$1)\quad \left\{ \left[\frac{\text{Fraction of grain in storage which would be undeteriorated at the end of an additional year if stocks were replaced}}{\text{Fraction of grain in storage which would be undeteriorated at the end of an additional year if stocks were } \textit{not} \text{ replaced}} - 1 \right] \left[\begin{array}{l} \text{Initial price of grain} \times \text{fraction of grain in storage which is undeteriorated} + \\ \text{discounted cost of carrying a bushel of grain for an additional year} \end{array} \right] \right\}$$

$$2)\quad \left\{ \begin{array}{l} \text{Discounted sum of the cost of putting a bushel of grain into storage and taking a bushel out of storage, the latter divided by the fraction of grain in storage which is undeteriorated.} \end{array} \right\}$$

If the first expression is larger than the second, it is cheaper to replace the stocks than to let them age further.[6] By applying this condition to each year, the times are discovered when stocks should be replaced. Three possible situations may be visualized, depending on the shape of the deterioration function. It may be profitable to replace the stocks every year, to replace them only occasionally, or never to replace them. When deterioration is by a constant percentage each year, as in (a) in Figure 2, only if the decrease in carrying cost made possible by storing less grain when stocks are replaced is greater than the cost of

TABLE 2. HYPOTHETICAL STOCK REPLACEMENT AND STORAGE COST

Year (n)	Replacement	Cost of Storage per Bushel for n Years	
		Under assumptions in text	If cost each year were $.136
1	Not replaced	$.136	$.136
2	Not replaced	.255	.265
3	Replaced	.408	.389
4	Not replaced	.562	.506
5	Not replaced	.714	.617

replacing will replacement be profitable. The conjecture may be made that this case is not likely and that hence stocks would probably never be replaced, or, if this case did occur, that stocks would be replaced every year.[7]

The way in which replacement affects storage cost calculations has already been mentioned. A numerical example is summarized in Table 2 which, as well as illustrating the replacement decision, further exemplifies the calculation of costs. In the example the price of the grain is assumed to be $2.00 per bushel (unchanged over the entire period considered),

[6] This condition is derived in the appendix.
[7] See, however, the consideration of this case in the appendix.

the cost per bushel of putting it into storage $.01, the cost of taking it out $.01, the cost of carrying it $.01, and the rate of interest 5 per cent. The assumption about deterioration is that for every bushel in storage, there is one-twentieth bushel deterioration each year.[8] By applying these values in the condition stated above, it is found that during the first five years stocks would be replaced once—at the end of the third year. In illustrating how the figures in the table were derived, the cost of storage for four years may be considered. Since the stocks are replaced at the end of the third year, every bushel taken out at the end of the fourth year will be the equivalent of 1/.95, or 1.0527 bushels put in a year before, due to deterioration. Similarly every bushel replaced at the end of the third year is the equivalent of 1/.85, or 1.1765 bushels put in at the beginning of the first year. Thus, to have one bushel at the end of four years, 1.0527 times 1.1765, or 1.2385 must initially be put into storage. The cost of putting this amount into storage at the present time is $.01 times 1.2385, or $.012385. Now consider the replacement costs incurred at the end of the third year. The cost of taking the original amount out of storage is $.01 times 1.2385 discounted at 5% for three years, or $.0107236. The cost of putting back into storage an equivalent amount of undeteriorated grain is $.01 times 1.0527 similarly discounted, or $.009072. The cost of finally taking the grain out at the end of the fourth year is $.01 times 1.0527 discounted for four years, or $.0086415. The carrying costs will be the sum of the discounted costs of carrying 1.2385 bushels in the first three years and of carrying 1.0527 bushels in the fourth year, or $.044494. Finally, since for every bushel finally taken out, .2385 bushels at $2.00 a bushel have deteriorated, deterioration costs are $.4770. The cost of storing per bushel for four years is, then, the sum of all these costs, $.562.

Storage costs are usually spoken of as so much per bushel per year, and it is convenient to be able to do this in analysis not directly concerned with replacement since the age of stocks and turnover costs can be ignored. In the table, the cost of storing for a given number of years is also given assuming that costs are the same in every subsequent year as they are in the first year. Thus, the cost of storing for n years is simply the sum of $.136 discounted each of the n years. By comparing this cost with the "true" costs as derived above, it is possible to see how much error would be involved in treating costs as if they were $.136 each year. In the example here, this assumption might not yield too bad an approximation, although the error reaches about 15% by the fifth year. The numerical example has been included only for illustrative purposes, however, and is not intended to indicate what the situation might be if estimates

[8] That is, deterioration is one-twentieth of the total of both deteriorated and undeteriorated grain in storage, a case such as depicted in (c) of Figure 2.

based on empirical data were used. A crucial assumption is that of how grain deteriorates through time. In reality, deterioration depends on activities such as fumigating and turning, the extent of which is also subject to cost minimization, problems which, for simplification, have not been dealt with here.

APPENDIX

Location of Stocks. Let S = the amount of grain to be stored, s_1 = the amount stored in the first locality, and s_2 = the amount stored in the second locality, so that $s_1 + s_2 = S$. Let $x_1^{(i)}$ and $x_2^{(i)}$ be the amounts produced in the i^{th} year in the two localities and $y_1^{(i)}$ and $y_2^{(i)}$ the amounts used in the two localities in the i^{th} year. Let the present year be time period 0 and the year when the stored grain is to be used be time period n. Let r be the rate of interest, b_1 and b_2 the unit cost of storing for the n years in the two localities, and d the unit cost of transporting grain between the two localities.

Case II-b-1 in Table 1 which was discussed in the text is represented below. All the other cases can be represented similarly:

$$\text{If} \begin{cases} -S < y_1^{(0)} - x_1^{(0)} < 0 \\ S > y_1^{(n)} - x_1^{(n)} > 0 \\ (y_1^{(n)} - x_1^{(n)}) + (y_1^{(0)} - x_1^{(0)}) > 0 \end{cases}$$

$$\text{Then} \begin{cases} s_1 = S,\ s_2 = 0 \text{ when } b_1 < b_2 - d\left(1 + \dfrac{1}{(1+r)^n}\right) \\ s_1 = (y_1^{(n)} - x_1^{(n)}),\ s_2 = S - s_1 \\ \qquad \text{when } b_2 - d\left(1 + \dfrac{1}{(1+r)^n}\right) < b_1 < b_2 - d\left(1 - \dfrac{1}{(1+r)^n}\right) \\ s_1 = x_1^{(0)} - y_1^{(0)},\ s_2 = S - s_1 \\ \qquad \text{when } b_2 - d\left(1 - \dfrac{1}{(1+r)^n}\right) < b_1 < b_2 + d\left(1 + \dfrac{1}{(1+r)^n}\right) \\ s_1 = 0,\ s_2 = S \text{ when } b_1 > b_2 + d\left(1 + \dfrac{1}{(1+r)^n}\right) \end{cases}$$

Type of Facilities. Let c_1 and c_2 refer to the unit cost of capacity of the two types of facilities, b_1 and b_2 to the variable costs of storing, x_i to the amount of storage in the first type of facility in the i^{th} year, y_i to the amount of storage in the second type of facility in the i^{th} year, z_i to the total amount of storage in the i^{th} year (so that $x_i + y_i = z_i$) and r to the rate of interest. Let $z^{(1)}, z^{(2)}, \ldots, z^{(m)}$ refer to the ordering of future amounts of total storage by size, where $z^{(1)}$ is the smallest amount and $z^{(m)}$ the largest.

The total cost of storage is then

$$x^{(m)}c_1 + b_1 \sum_{i=1}^{i=n} \frac{x_i}{(1+r)^i} + y^{(m)}c_2 + b_2 \sum_{i=1}^{i=n} \frac{y_i}{(1+r)^i}.$$

The rule for minimizing this expression is: Make $x^{(m)} = z^{(j)}$ for the largest j where

$$c_1 - c_2 < (b_2 - b_1)\left(\sum_{i=1}^{i=n} \frac{\alpha_i^{(j)}}{(1+r)^i}\right) \begin{cases} \alpha_i^{(j)} = 0 \text{ when } z_i < z^{(j)} \\ \alpha_i^{(j)} = 1 \text{ elsewhere.} \end{cases}$$

Figure 1 is based on the assumptions that $c_1 - c_2 = \$.20$, $b_2 - b_1 = \$.10$, $z_1 (= z^{(2)}) = 3$ million bushels, $z_2 (= z^{(4)}) = 5$ million bushels, $z_3 (= z^{(3)}) = 4$ million bushels, $z_4 (= z^{(1)}) = 2$ million bushels, and $r = 5$ per cent. The slope of the cost curve is simply the above expression with the inequality replaced by a plus sign. Between zero and $z^{(1)}$ the slope in Figure 1, in cents per bushel, is -20.45; between $z^{(1)}$ and $z^{(2)}$, -12.23; between $z^{(2)}$ and $z^{(3)}$, -2.70; and between $z^{(3)}$ and $z^{(4)}$, 5.93.

Stock Replacement. Let q_i = number of bushels in storage at the end of the i^{th} year, c = carrying cost per bushel per year, a = cost per bushel of putting grain into storage, b = cost per bushel of taking grain out of storage, P_0 = present price of grain, and r = rate of interest. Let the deterioration function be $f(t)$ and the age of the stocks g. The cost incurred if stocks are not replaced at the end of the i^{th} year is then $\frac{q_{i+1}}{f(g+1)}\left\{P_0[f(g) - f(g+1)] + \frac{c}{(1+r)^i}\right\}$.

If stocks are replaced, the cost is

$$\frac{q_{i+1}}{f(1)}\left\{P_0[1 - f(1)] + \frac{c}{(1+r)^i}\right\} + \frac{q_{i+1}}{f(1)} \cdot \frac{a}{(1+r)^i} + \frac{q_{i+1}}{f(1)f(g)} \cdot \frac{b}{(1+r)^i}.$$

The condition under which the first expression is larger than the second and hence when it will be cheaper to replace stocks instead of letting them age further is $P_0\left[\frac{f(1)f(g)}{f(g+1)} - 1\right] + \frac{c}{(1+r)^i}\left[\frac{f(1)}{f(g+1)} - 1\right] > \frac{a + b/f(g)}{(1+r)^i}$.

This result, which is seen to be independent of the q's, is given verbally in the text in a slightly different form.

With constant percentage losses, $f(1)\,f(g)$ is equal to $f(g+1)$, and the value of the first bracket is zero. The condition for replacement becomes

$$\frac{1}{f(g)}[c - b] > a + c.$$

Replacement is thus more likely the smaller "in" and "out" costs are relative to carrying cost. If $b > c$, the condition is never met. Since, however, $1/f(g)$ increases with g, if $b < c$, it is conceivable that, contrary to the conjecture in the text, intermittent replacement would be called for.

HEDGING RECONSIDERED

HOLBROOK WORKING
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DURING the past fifteen years, at least four studies have been published which sought to measure the effectiveness of hedging in commodity "futures."[1] Each of these inquiries sought to test the effectiveness of hedging by comparing changes in spot prices of one or more commodities with simultaneous changes in futures prices. In each case, effectiveness of hedging was judged in terms of the degree of correspondence between changes in spot prices and simultaneous changes in futures prices.

It would be profitable to review these studies from the standpoint of the contributions that each has made to the very pertinent questions that they set out to treat, but instead we must get on directly with examining an unexpected problem that they have raised. This problem is posed most sharply by some of the results of the latest of the four major inquiries referred to. These are reproduced in Table 1. From these figures

TABLE 1. CALCULATED GAINS AND LOSSES PER BUSHEL ON STORAGE OF GRAINS UNDER HEDGE, 1949–1951*
(*Averages in cents per bushel per eight-week period*)

Year	Wheat	Corn	Oats
1949	−3.24	−1.98	−1.89
1950	−2.34	−1.67	−2.42
1951	+1.37	+ .13	+1.54

* Data from Truman F. Graf, "A Critical Analysis of Hedging on the Chicago Board of Trade During the Years 1949–1951," *Proceedings, Fifth Annual Symposium, Chicago Board of Trade*, Second Appendix (Chicago, 1952, mimeographed), p. 24.

it appears that storage of wheat with hedges in Chicago wheat futures would have resulted in 1949 in an average loss of 3.24 cents per bushel per eight-week period. This loss is calculated simply on the basis of price changes, making no allowance for the costs of storing the wheat, nor any allowance for brokerage fees or other costs of purchase and sale of either the spot wheat or the futures used as hedges. Similar calculations show

[1] L. D. Howell and Leonard J. Watson, *Relation of Spot Cotton Prices to Prices of Futures Contracts and Protection Afforded by Trading in Futures*, U. S. Department of Agriculture, Technical Bulletin No. 602 (Washington, 1938); L. D. Howell, *Analysis of Hedging and Other Operations in Grain Futures*, U. S. Department of Agriculture, Technical Bulletin No. 971 (Washington, 1948); B. S. Yamey, "An Investigation of Hedging on an Organized Produce Exchange," *The Manchester School*, XIX, 305-19 (September, 1951); Truman F. Graf, "Hedging—How Effective Is It?" *This Journal*, August 1953 (an earlier, mimeographed, paper by the same author with more statistical data is cited in connection with Table 1 above.

an average loss of 2.34 cents per bushel per eight-week period on storage of wheat in 1950, and an average gain of 1.37 cents per bushel per eight-week period in 1951. Results shown for storage of corn and oats are similar to those for wheat. For each grain, losses are indicated in two out of three years, and the gain indicated in the third year is smaller than the loss in either of the other two years.

These are surprising figures, and very puzzling when considered in the light of the wide use of futures markets for hedging and the high valuation placed on hedging by virtually all businessmen who have expressed themselves on the subject. Consider for example, an extract from a letter written by an experienced flour miller in Minneapolis to a younger man who was entering the milling business in Canada.

"You must," the older man wrote, "aim for the highest quality of output and the largest amount possible, at the least average cost per bushel. . . .

"I have never tried to make money by forecasting the market. I have noticed that my competitors that have done this continuously have, as a rule, failed in business. We have always kept our stocks of wheat either sold in the shape of flour, or in sales of options for future delivery in both the Minneapolis and Chicago markets—the options being bought back when sales of flour required. In times such as were experienced during the Leiter corner, when we could not sell flour based on the daily market price of wheat, we closed our mills and delivered the wheat."[2]

This letter was written in 1903, by William Hood Dunwoody, one of the founders of the milling concern whose practice he described. His firm has continued to prosper, and has grown into General Mills, Inc. It is as devoted to hedging today as it was fifty years ago when Mr. Dunwoody wrote this letter.

Mr. Dunwoody's firm has not reached its present position in the milling industry by following a practice that led to heavy losses in two years out of three. Hedging would not have the reputation that it does among experienced hedgers generally, and among their bankers, if its results were anything like those represented by the calculations that we have just considered. What is wrong with the calculations?

To find the answer to this question we must examine the purposes and consequences of hedging as it is actually practiced. In the process we shall quickly discover, as often happens in scientific inquiry, that resolving the conflict of evidence leads on to something more important. This conflict arose because the attempted tests were based on a prevalent conception of hedging that is partially mistaken; we shall seek to do more than find fault with the prevalent concept.

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[2] The Northwestern Miller, May 15, 1951, p. 26.

Hedging by Warehousers

We may consider first the hedging done by those who make a business of carrying large stocks of a commodity at appropriate times. In the grain trade a great part of such stock-carrying in recent years has been done by the federal Commodity Credit Corporation, or by growers holding stocks under non-recourse loans. Such stocks, though carried in commercial storage elevators, give rise to no hedging. Formerly, most of the grain held in large storage elevators[3] was owned by the elevator operators, and even during recent years there have been occasions when operators of storage elevators owned large stocks. Large stocks thus owned are almost always hedged.[4]

The expression "stocks are hedged," though useful for brevity, may be misleading. It applies equally to cases where certain stocks would be carried whether hedged or not, and to cases where the stock-carrying is directly dependent on the hedging. In the long-period commercial storage of wheat, for example, the volume of stocks carried by a storage elevator at any time depends largely on the fact that the elevator hedges. In the absence of futures trading and hedging, accumulation of surplus stocks must be done on the basis of highly uncertain expectations that the price will subsequently advance. In the presence of hedging, such accumulation is based on reliable evidence that the *relation* between spot and futures prices will change favorably to the stock-holder—that either the spot price will rise relative to the futures price or the futures price decline relative to the spot. The hedger who engages in storage of surpluses therefore carries the stocks he does because he hedges.

Predictions of wheat price changes are notoriously unreliable, as are predictions of price changes in any storable farm product that is traded on a relatively free market.[5] Predictions of change in relation between spot and futures prices, on the other hand, are easily made with good reliability. The principal basis for prediction at any time is simply the current relation between spot and futures prices, or between prices of near

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[3] The term "storage elevator" is used here to designate elevators operated in significant part at least for storage other than that done purely as an adjunct to a merchandising or processing business. The distinction may seem a difficult one in view of the fact that most storage elevators are operated by firms that do a merchandising business, yet we shall see later that there are marked differences in storage practice which require the making of such a distinction.

[4] The most comprehensive summary of evidence on the prevalence of hedging by different groups in the grain trade, though out of date in some respects, is still that of the Federal Trade Commission, *Report on the Grain Trade*, VII, 43-60 (Washington, 1926). For a discussion of the relation of hedging to the development of futures trading, see Holbrook Working, "Futures Trading and Hedging," *American Economic Review*, XLIII, 318-20 (June 1953).

[5] Perishability of a product favors predictability of price change because it tends to eliminate expectations regarding subsequent prices as current price influences.

and distant futures. Recognition of the predictive value of such a price difference is reflected in the term commonly applied to it in the trade, "carrying charge."

Chart 1 illustrates the degree of reliability of such a basis for predicting the changes in price relations on which a hedger depends for profits from storage.[6] It is apparent from Section A that the spot premium for wheat at Kansas City on September 1 has indicated well the financial results to be expected from storage of wheat by a hedger during the subsequent three months. The coefficient of correlation between the spot premium on September 1 and the gain or loss subsequently realizable is $r = -.839$.

Section B of Chart 1 shows similarly potential gains and losses from carrying hedged stocks of wheat between May 1 and July 1, in relation to the spot premium on May 1. The correlation in this instance is $r = -.975$. Gains, when they were available, tended to be about one-third less on stocks carried between May and July than on stocks carried between September and December, primarily because the storage period was two months rather than three months. In years when stock-holding would have resulted in a loss, however, the losses over the May-July interval, during which new crop supplies become available, would often have been much larger than over the September-December interval.

Since the relation between spot and futures prices gives in advance a fairly reliable indication of prospective gain or loss from storage by a hedger, it is obviously unreasonable to calculate possible financial results associated with hedging in the manner by which the data of Table 1 were obtained. That calculation assumed implicitly that the volume of stocks on which hedgers would take losses were as large as the volume on which they would take gains.

Moreover, the basic idea that complete effectiveness of hedging depends on parallelism of movement of spot and futures prices is false, and an improper standard by which to test the effectiveness of hedging. The effectiveness of hedging, intelligently used in connection with com-

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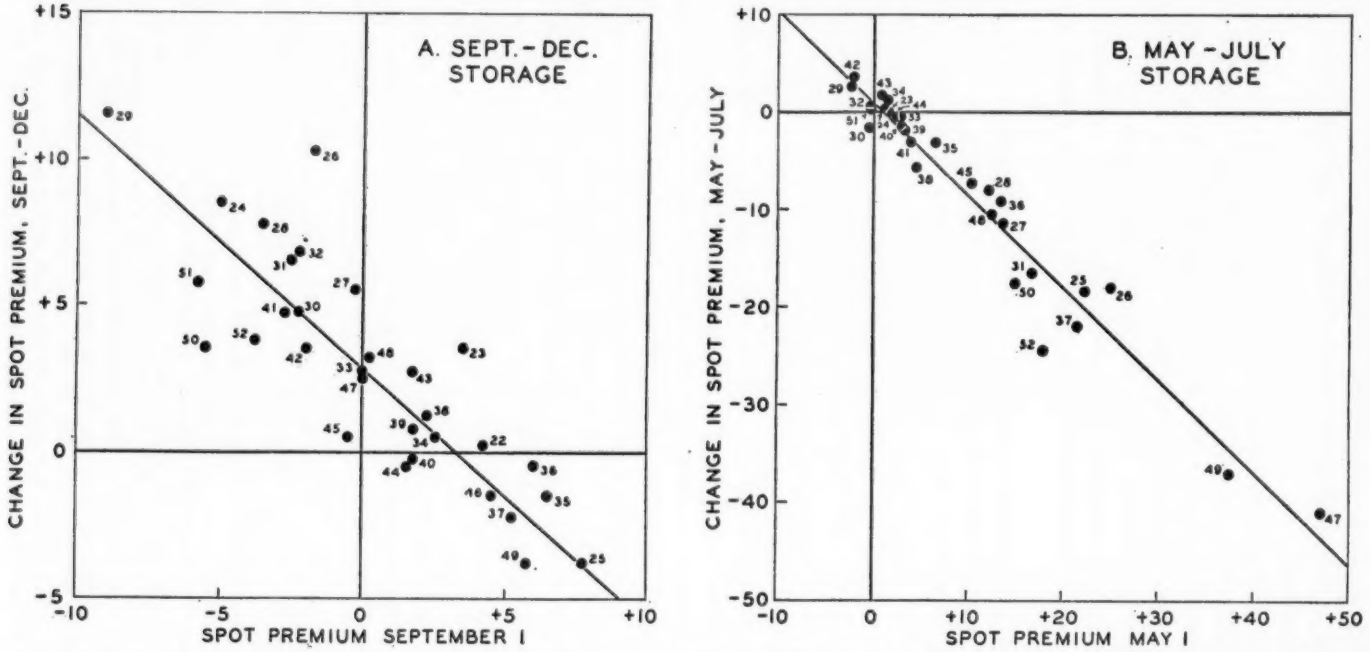
[6] Kansas City rather than Chicago prices are used because for many years spot transactions in wheat on the Chicago Board of Trade have been too infrequent to afford good spot quotations.

The horizontal scale shows the relation on the first trading day of September between the carlot price "on track" of the cheapest quoted wheat of a quality deliverable on Kansas City futures and the price of the December future. This price difference is designated for brevity as a "spot premium," discounts being treated as negative premiums. The vertical scale shows for each year the change in relation of the spot price to the price of the December future between the first trading day of September and the first trading day of December. This change in the quoted spot premium measures the gross gain or loss that would be realized by a hedger from storage over the interval, but probably does not reflect much of the merchandising gain which also is obtained by a storage elevator.

CHART 1.—RELATIONS OF SPOT PREMIUMS FOR WHEAT AT KANSAS CITY ON SEPTEMBER 1 AND MAY 1 TO GAIN OR LOSS FROM SUBSEQUENT STORAGE OF HEDGED WHEAT, 1922-1952*

(Cents per bushel)



* Data compiled from Kansas City *Grain Market Review;* the spot premium used is that of the lowest quality No. 2 Hard Winter wheat, on track, taken in relation to the price of the Kansas City December (Section A) or July (Section B) future. The correlation coefficients and regression equations are: A, $r = -.839$, $y = -.861x + 2.87$; B, $r = -.975$, $y = .946x + .980$.

modity storage, depends on *inequalities* between the movements of spot and futures prices and on reasonable predictability of such inequalities.[7]

Operational Hedging

Processors of commodities commonly provide themselves with only such storage space as seems a necessary adjunct to their processing business, and make little effort to gain profits simply from storage of the commodity. Many merchants operate similarly. The most complete and extensive data available on hedging practice of such commodity handlers

TABLE 2. INVENTORY POSITION OF REPORTING FLOUR MILLS, JUNE 30 AND SEPTEMBER 30, 1947–52*
(*Million bushels of wheat or wheat equivalent of flour*)

Year	Stocks, Wheat and Flour	Purchase Contracts, Wheat (Futures)	Sales Contracts		Excess of Stocks over Flour Sold[b]	
			Flour (Unfilled orders)	Wheat (Futures)	Hedging Mills	Non-hedging Mills
			JUNE 30			
1947	53.6	9.2	53.4 (28)[a]	13.5	4.3	(4.1)[c]
1948	51.1	12.6	44.3 (24)	16.7	4.1	2.7
1949	39.8	13.1	31.5 (16)	11.6	(1.5)[c]	9.8
1950	50.0	7.8	45.3 (24)	10.5	2.7	2.0
1951	71.2	2.5	49.0 (28)	21.6	19.1	3.1
1952	65.4	10.2	60.1 (32)	13.7	3.5	1.7
Average	55.2	9.2	47.3	14.6	4.3	2.6
			SEPTEMBER 30			
1947	134.3	14.5	110.3 (61)	29.6	15.1	8.9
1948	104.4	11.8	69.7 (37)	33.8	22.0	12.7
1949	97.8	8.5	73.0 (39)	20.0	11.5	13.4
1950	112.4	14.2	104.6 (56)	17.4	3.1	4.5
1951	118.8	10.6	100.7 (53)	23.6	13.0	5.1
1952	113.9	16.0	109.9 (59)	15.1	(.9)[c]	4.8
Average	113.6	12.6	94.7	23.2	10.7	8.2

* Data from reports to the Miller's National Federation, published here by kind permission of the Federation.

[a] Figures in parentheses are the number of days of capacity operation represented by unfilled flour orders.

[b] The segregation below between hedging and nonhedging mills is based on the assumption that mills which hedged in wheat futures were completely hedged.

[c] Unfilled orders in excess of stocks.

are the rich accumulation of information on inventories of wheat flour mills collected by the Millers' National Federation.[8] Table 2 reproduces

[7] This important fact, so briefly stated here, is more fully developed in Holbrook Working, "Futures Trading and Hedging" *American Economic Review* XLIII, 320-25 (June 1953).

[8] The data apply to quarterly dates beginning with June 1926, and in recent years cover mills that were currently producing about 80 percent of the total United States flour output.

coefficients and regression equations are: A, r = —.839, y = —.861x + 2.87; B, r = —.975, y = .946x + .980.

a portion of this information for the end of June and of September of each of the last six years. These are the quarterly dates when mill stocks of wheat and unfilled flour orders were lowest, and highest, respectively.

It will be noticed that unfilled flour orders on June 30 ranged in volume from an amount representing 16 days of mill operation to 32 days. Forward sales of flour on September 30 were always larger than on June 30, ranging in amount from 37 days of mill operation to 61 days. Since mills now customarily operate on a 5-day week, 61 days of operation would cover about twelve calendar weeks, or nearly three months.

Flour mills hedged, in the broad sense, mainly by keeping stocks of wheat and of flour (chiefly wheat) in fairly close balance with their volume of forward sales of flour (sales contracts). Stocks carried, on the average, were some 15 to 20 percent in excess of unfilled flour orders.[9] The mills contributed significantly to the carrying of *seasonal* wheat surpluses, their stocks on September 30 of these years having averaged more than twice as large as their stocks on June 30, but they appear to have done so mainly because flour buyers placed forward orders in large volume at the time of seasonal surplus.

The figures on excess stocks in the last two columns of Table 2, because they are net for all mills in each category, tend to give an inadequate impression of the amount of business risk against which hedging mills were protected through use of futures contracts, and of the amount of risk which nonhedging mills carried without such protection. The commitments on which hedging mills carried protection at the end of September 1951 is better measured by the *sum*, $10.6 + 23.6 = 34.2$ million bushels, than by the net figure of 13.0 million bushels. Similarly, nonhedging mills carried risks on excess stocks *and* on excess flour sales which must have totalled considerably more than the net figure of 5.1 million bushels. The net figures, being the only ones available for nonhedging mills, are nevertheless well worth study.

Visual comparison of the last two columns of Table 2 suggests little correspondence in behavior between hedging mills and nonhedging mills as regards excess stocks carried at the end of either June or September. This impression coincides with results of thorough statistical analyses

[9] On September 30, 1951, for example (a fairly typical case), the mills represented in the table held unfilled orders for flour equivalent to 100.7 million bushels of wheat, and their stocks of wheat and flour totalled 118.8 million bushels (of which 11.6 million bushels was the wheat equivalent of flour stocks on hand). Their stocks, therefore, exceeded the wheat equivalent of their forward sales of flour by 18.1 million bushels.

Mills that practice careful hedging commonly carry hedges in the millfeed futures (bran and shorts) as well as in wheat; having made a forward sale of flour, such a mill will hedge by buying wheat futures and selling millfeed futures. The available data on mill hedging, however, do not include information on millfeed inventory and contracts.

that I have made, using similar data for additional years as well as those shown here, and data for the other two quarterly reporting dates also.[10] The excess stocks of nonhedging mills evidently have been influenced in the main by quite different circumstances than influenced the excess stocks of hedging mills.

There is a fairly clear and simple pattern of behavior in the excess stocks of nonhedging mills. Stocks of these mills tended to substantially exceed unfilled orders when the volume of unfilled orders was small for the time of year, and to be relatively small (excess stocks small or slightly negative) when unfilled flour orders were large.[11] This behavior, clearly evident in the data of Table 2, is doubtless partly a reflection of the fact that the nonhedging mills include many country mills that must to a large extent acquire wheat supplies when growers are selling. Their stocks must be allowed to vary more or less independently of the current state of unfilled orders, and therefore their *excess* stocks tend to vary inversely with the volume of unfilled orders. In part, however, and perhaps in larger part, the behavior of excess stocks of nonhedging mills may reflect rule-of-thumb adjustment of stocks in unnecessary disregard of the current volume of unfilled flour orders.

The excess stocks of hedging mills, on the other hand, follow no clear pattern that I have been able to discover. Indeed, there is positive evidence that they follow no common pattern. If excess stocks of hedging mills tended to depend on some set of influences that affected most hedging mills similarly, there would be a strong tendency for the aggregate long position in futures of hedging mills to be small whenever the aggregate short position was large, and vice versa. In fact, however, the totals of long and short futures positions of hedging mills have been substantially uncorrelated. Apparently hedging mills accumulate stocks in excess of unfilled orders, or accept orders in excess of their stocks, according to conditions that vary so much from mill to mill and from one section of the country to another that no dominant pattern of behavior emerges. In view of the apparent absence of substantial general influences affecting the excess stocks of hedging mills, the variations that do occur are particularly significant as evidence of the freedom that hedging gives for

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[10] The full evidence on this point and on other points which Table 2 illustrates would occupy too much space for inclusion here.

[11] Excess stocks of hedging and of nonhedging mills, as shown in the table, are excesses over the unfilled orders of the particular group of mills for which the excess is shown, but the data allow comparison of the excesses only with unfilled orders of all reporting mills combined. The combined figure is probably not a very precise index of unfilled orders of nonhedging mills by themselves. I am surprised that the combined figure seems to serve as such an index so well as it does, in view of the possibilities for unfilled orders of hedging mills to move differently than unfilled orders of nonhedging mills.

adjustment to the special conditions in which a mill finds itself. The data for June 30, 1949 offer a striking example.

We should now turn from the statistics and examine the conditions under which flour mills operate, seeking in them an explanation of the sort of hedging behavior observed.[12] There are two questions which particularly call for answer. First, why do flour mills hedge in futures at all, in view of their general practice of keeping stocks and forward orders fairly close to equality? Their risks even if they did not hedge would be relatively small. And second, why do mills that hedge show such great variations among themselves at any time in their individual balances between stocks and unfilled orders?

There is no major "organized" market for flour. Large flour buyers purchase directly from the mills, getting competitive offers from several mills before making each purchase contract. Each mill, in calculating the price at which to offer flour for sale, must include three elements in the calculation: (1) the milling margin judged to be available in the current state of mill competition; (2) the prices at which mill byproducts can be sold; and (3) the cost of the raw material, wheat. The last is the largest of the three items. Though we concentrate attention on it, similar considerations apply in calculating the allowance to be made for returns from mill byproducts.

Because flour sales arise largely from competitive offers made simultaneously by several mills, the mill sales manager must seek especially to calculate wheat costs in such a way that actual costs will not tend to prove larger than estimated *in those cases when the price he quotes is below the prices of other mills.* It is not sufficient that his estimates of cost be high enough on the average, they must be high enough in those particular cases when the price he quotes is low enough to lead to a sale. This means that he must calculate flour prices on the basis of *current* wheat prices. He must not quote on the basis of costs of wheat already bought, because then he could make no sales when wheat had been bought above current prices. And he must not quote on the basis of prices at which he expects to be able to buy wheat a few weeks later, because his expectations will often be mistaken and even though his expectations are more often above than below the prices that eventuate, the offers of flour that lead to sales will tend to be principally those based on cost expectations that were too low.

The need for pricing flour as though the cost of wheat to fill each

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[12] What follows draws partly on a paper by the President of the Commander-Larabee Milling Company: Ellis D. English, "The Use of the Commodity Exchange by Millers," *Proceedings, Fifth Annual Symposium Chicago Board of Trade* (Chicago, 1952, mimeo.) pp. 22-29.

order were determined by current wheat prices does not necessarily mean that wheat enough to fill each order should be bought promptly after the order is obtained. A mill might logically, and if favored by good market judgment, profitably, exclude expectations when offering flour for sale, yet take them into account when timing wheat purchases. In practice this is likely to be difficult. If expectations are allowed to influence the timing of wheat buying, not in itself a particularly dangerous practice, it may be hard to keep expectations out of the calculations made in pricing flour, which tends to be disastrous. And if each large sale of flour is to be matched immediately by an equivalent purchase of wheat, the purchases must usually be of futures (involving hedging), for reasons to be considered presently.

In any case, whether hedging is practiced or not, the needs of flour pricing favor use of futures prices of wheat in arriving at the flour price to be quoted. Under most circumstances in the United States the most accurate way for a miller to estimate the current market price of a particular quality of wheat is by reference to the latest futures quotation, adding to it or substracting from it an appropriate price differential based on price relations observed in connection with recent sales of that quality of wheat.

We should now pursue the observation above that if a large flour sale is to be matched immediately by purchase of an equivalent amount of wheat, the purchase must usually be of futures. This is so because the futures market is one in which "bid" and "asked" prices, even for large quantities, rarely differ by more than a small fraction of a cent per bushel. As much as 100,000 bushels of wheat can almost always be bought on the futures market, on a moment's notice, at a price not more than ⅛ or ¼ cent per bushel above the last price at which a sale was made. To buy that amount of wheat in the spot market, a miller must choose between buying in driblets over days or weeks, as the wheat arrives from the country, or buying from an elevator operator who has the wheat in store, but who asks a price that includes his dealer's margin. And even if the purchase is to be made from an elevator, time may be needed for "shopping" among several elevators, and a good deal of bargaining may have to be done to avoid paying an unnecessarily high price. So if wheat is purchased immediately to cover a large flour sale, the purchase is usually made in a futures market.

Thus a mill may be led to buy futures immediately after each sale of flour—that is, to hedge—for reasons quite unconnected with any need or special wish to avoid risks of price change, in the usual sense. If so, the "hedge" in futures should not be regarded as an offset to the forward sale of flour, but as a *temporary substitute* for a purchase of spot wheat. Indeed, any hedging purchase or sale of futures is a temporary substitute

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for a "cash" purchase or sale, regardless of the reason for choosing to hedge.

Similarly, if the mill sells futures against each purchase of wheat, the mill buyer is free to buy lots of the desired qualities whenever he can get them at prices that seem low, or at least not unduly high, in relation to a futures price. The advantages to the sales manager in quoting a price for flour and to the mill buyer in timing his purchases of wheat explain why mills hedge in futures even though they are able to keep stocks and forward orders sufficiently well balanced to have no need for other protection against the risks of price change.

As for the second question raised by the data on hedging, the appearance of almost random diversity among mills as to whether they carry excess stocks at a given time or allow stocks to fall behind orders may arise chiefly from the tendency for flour sales to be made intermittently and competitively. Mill buying of wheat continues in the intervals between the making of large forward sales of flour, tending toward the accumulation of excess stocks; but when any large flour sale is made, it tends to push unfilled orders above the level of stocks of the particular mill that receives the order. Diversity among mills in excess stocks carried at any time arises also from diversity in judgments among mill buyers, and from regional differences in opportunities for advantageous buying. A contributing factor in the case of exceptional diversity on June 30, 1951, cited earlier, was that millers in spring-wheat territory tended to be well stocked with old wheat, while those in winter-wheat territory had largely exhausted their stocks of old-crop wheat and had not yet, as of June 30, replaced them with much new-crop wheat. And of course the excesses of stocks among the one group and of forward orders among the other had been allowed to grow or remain so large partly because the mills, having hedged, were protected against the major risks of price change. Inequality between stocks and forward orders for any mill may be largely a result of hedging rather than a cause.

Neither of the two main types of hedging that we distinguish is well characterized by the conventional description of hedging. Hedging done in connection with the carrying of surplus stocks is misrepresented by the usual implication that spot and future prices should change equally, since in fact such hedging draws its great advantage from existence of predictable disparity of movement between spot and futures prices. In operational hedging, as represented by the hedging of wheat flour mills, it would be convenient if spot and futures prices did change equally, yet the usual actual tendency toward gradual divergence in their movement is of little consequence because such hedging commitments tend to be held for only short periods. On that account, however, the losses

risked by failure to hedge would be small, so that the wide prevalence of operational hedging is not explained by need to avoid such risks. We find the explanation more largely in the merits of hedging as an aid to efficient and profitable operation in buying and selling.

Economic Effects of Hedging

The foregoing inquiry into the chief business uses of hedging puts us in position to summarize its major economic effects. Those to be considered are of three sorts, and the first two will engage our attention only very briefly.

The reduction of business risks consequent on hedging is commonly credited with reducing margins between the price received by the producer and that paid by the consumer. This seems a valid inference. And reduction of risk tends to mean fewer business failures, with consequent social advantages in addition to the economic ones. Hedging does reduce business risks, as we have seen. It not only restricts the amount of risk incurred in holding excess commodity stocks or excess forward commitments, it also reduces the risk that unwise holding of the commodity will be undertaken, or unwise forward commitments made.

A second economic advantage of hedging is that its widespread practice tends to diminish the vagaries of spot prices. This effect stems from the fact that a hedger can judge better, and more closely, what price he can afford to pay than a buyer who does not use a futures market in connection with his spot purchases. The consequent improvement in buyer's judgment doubtless results sometimes in lower prices to growers than they would receive otherwise, but the overall effect is probably a higher return to growers, since a buyer who is uncertain what price he can afford to pay usually tries to give himself the benefit of the doubt. This is an effect of hedging that deserves more consideration than it has had.

With these brief comments on two effects of hedging we turn to a third effect which may be the most important economically, at least as regards major farm products of the United States. This is the effect that hedging has of promoting the stockpiling of commodities in private hands in times of surplus, inducing the economical storage of such stocks, and prompting their release for consumption at appropriate times.

We have seen how hedgers may be led to govern the stocks they hold according to the relation of spot to futures prices. Chart 1, considered earlier, shows that spot-future price relations may be a highly serviceable guide in the control of inventory. Is it a guide that effectively encourages stockholding when there are in fact surplus stocks which need to be held, and that discourages stockholding when supplies are short?

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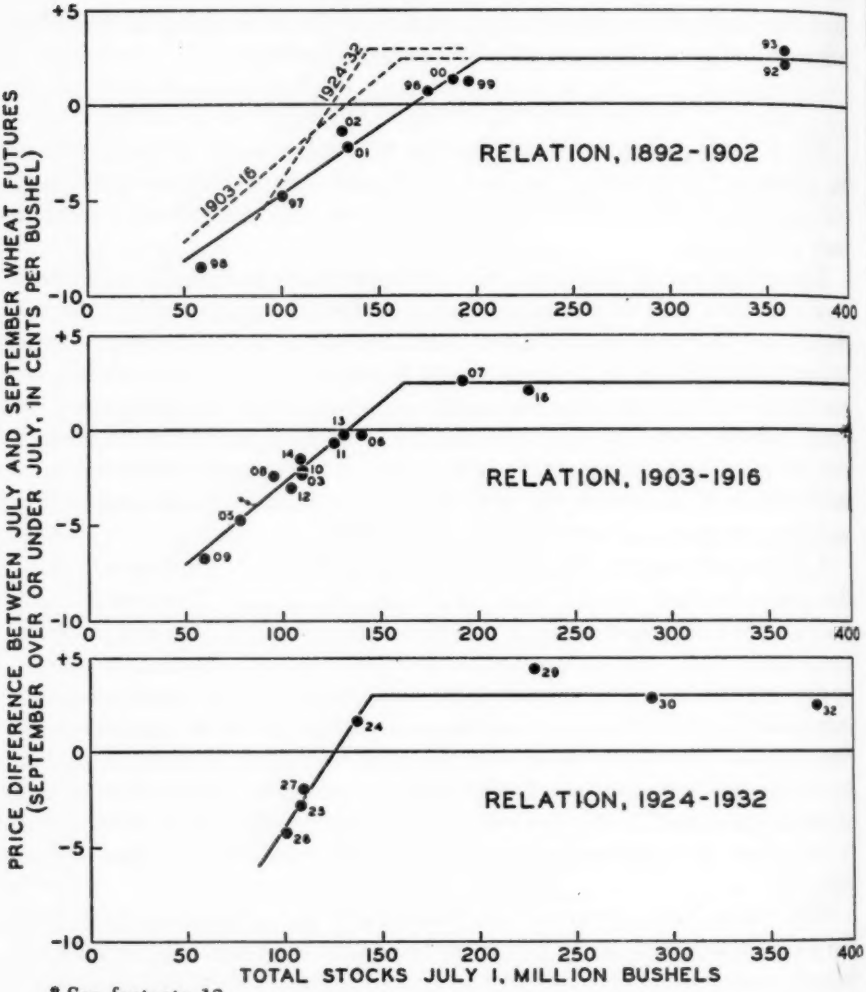
CHART 2.—RELATION OF WHEAT STOCKS TO THE "CARRYING CHARGE" IN CHICAGO WHEAT FUTURES*



* See footnote 13.

Chart 2 speaks to this point.[13] In years of scarcity, when little wheat remained in the United States at the end of the crop year, the price of the

[13] The vertical scale shows the average price-difference during three weeks in June between the price of the July wheat future at Chicago and the price of the September future. This price difference should be a major factor in determining whether a hedger in Chicago futures will carry surplus stocks of wheat from one crop year to the next. The horizontal scale shows the total quantity of wheat remaining in the United States on June 30, customarily taken as the end of the wheat crop year.

The relations shown in Chart 2 represent a revision of conclusions first published

September future was well below the price of the July, giving hedgers a strong incentive to sell any stocks that they could spare rather than to transfer hedges to the September future and continue to carry the stocks.[14] It appears that in general, the smaller the total supply of wheat, the stronger was the incentive given for hedgers to dispose of unnecessary stocks.[15] But if wheat supplies were large enough to provide year-end stocks of over 130 million bushels (175 million bushels prior to 1902) the price of the September future stood above the price of the July, affording hedgers an assured return for storage.[16]

When hedgers have had the assurance afforded by a market "carrying charge" of about 2.5 cents per bushel, in the earlier years, for storage through the two months from July to September, or about 3 cents per bushel during the two decades after 1920, they have been willing to carry an amount of wheat limited only by their storage capacity.[17] Chart 2 shows no observable tendency for the carrying charge to have been larger when the carryover was 350 million bushels than when it was 200 million bushels.

All major classes of holders of wheat in the United States have tended to carry larger stocks at the end of a year of surplus than at the end of a year of shortage, but most groups of holders have rarely carried year-end stocks in times of surplus more than twice as large as the stocks held at

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in Holbrook Working, "Price Relations between July and September Wheat Futures at Chicago since 1885," *Wheat Studies*, IX, 206, (March 1933). The stocks estimates shown for July 1 of 1892 and 1893 (360 million bushels in each year) are rough, based primarily on wheat disposition data.

In order that the normal relationship may appear more clearly, data are here omitted for years when corners or squeezes (1904, 1915, 1917, 1921, 1922, 1928) or other exceptional circumstances (1923, 1931) affected the July-September price spread. Since 1932 the relationship has been complicated by operations of the Commodity Credit Corporation.

[14] There was always also a further incentive in such years from the fact that in these circumstances the spot price in June was at a premium over the price of the July future.

[15] The relation between prices of the July and September futures evidently depends on the volume of old-crop supplies, *not* on new-crop prospects. The same is true of the relation between prices of May and July futures; see Holbrook Working, "Price Relations between May and New-Crop Wheat Futures at Chicago Since 1885," *Wheat Studies*, X, 183-88, 199-203 (February 1934). A similar behavior has been demonstrated for Liverpool wheat prices in Sidney Hoos and Holbrook Working, "Price Relations of Liverpool Wheat Futures," *Wheat Studies*, XVII, 101-38 (November 1940).

[16] The level of July 1 stocks which constituted a surplus and led to positive "carrying charges" declined sharply after 1901 because of rapid expansion in winter-wheat production in areas where the crop is harvested and marketed early.

[17] The occasional occurrence of considerably larger price spreads between the two Chicago futures, as in 1929, is explained primarily by exceptional congestion of elevators in Chicago. The corresponding price spreads for Minneapolis and Kansas City futures in June of 1929 did not exceed about 3 cents per bushel.

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the end of a year of severe shortage. This is shown by the data in Table 3 for farmers, country mills and elevators, and "merchant" mills.[18] Only in one year of surplus did year-end stocks held by any of these groups much exceed twice the average for years of shortage. That was in 1932, when extraordinarily low prices gave added stimulus to holding by farmers. The so-called "commercial" elevators, however, reduced their stocks to as little as 16.1 million bushels at the end of one year of shortage, and carried more than ten times that amount at the end of a year of surplus

TABLE 3. DISTRIBUTION OF JULY 1 STOCKS OF WHEAT IN THE UNITED STATES, YEARS OF SHORTAGE AND YEARS OF SURPLUS*
(*Million bushels*)

Year	Total	On Farms	Country Elevators and Mills	Commercial Elevator	Merchant Mills
			Years of Shortage		
1925	108.4	28.6	25.3	28.9	25.6 (25.2)
1926	100.2	27.1	29.5	16.1	27.6 (29.9)
1927	109.5	26.6	21.8	21.1	40.0 (33.7)
Average	106.0	27.4	25.5	22.0	31.1 (29.6)
			Years of Surplus		
1929	228.4	45.1	21.5	90.4	51.3 (58.1)
1930	288.9	60.2	60.2	109.3	59.2 (47.5)
1932	375.5	93.7	41.6	168.4	71.7 (59.4)
Average	297.6	66.3	47.8	122.7	60.7 (55.0)

* Data, except as explained below, from U. S. Department of Agriculture.

* Figures in parentheses are mill stocks as reported to the Miller's National Federation, as for Table 2, but excluding flour. These regularly exceed 80 percent of the adjacent merchant mill figures principally because they show stocks *owned* by the reporting mills, partly elsewhere than in what are designated for the purposes of the main table as mill elevators.

that followed soon afterward. Their stocks at the ends of the three years of surplus averaged 5.5 times as large as at the ends of the three years of shortage.

It should be noticed that the years of shortage and of surplus, as classed in Table 3, were years of *world* shortage or surplus, not necessarily years of domestic shortage or surplus. The domestic wheat crop in one of the years of "surplus," 1929-30, was smaller than in either of two of the years of "shortage." No country that lacks a widely used futures market has shown any strong tendency, as has the United States, to adjust its year-end wheat stocks to the world supply situation.[19]

[18] The data are for the latest three years of shortage and of surplus, respectively, in which stockholding was not substantially influenced by governmental actions. Data for 1931 are omitted because almost the whole wheat surplus then was held by the federal Grain Stabilization Corporation.

[19] Cf. Holbrook Working, "The Changing World Wheat Situation," *Wheat Studies*, VI, 433-52 (September 1930).

This long-time tendency toward rational adjustment of stocks in the United States, prior to governmental intervention in stock-piling, may be attributable not only to the strong incentives to such adjustment by hedgers, but in some part also to a tendency for many of those who do not hedge to follow the indications of futures prices as to whether carrying of stocks or placing of forward orders is likely to prove profitable or not.

An interesting question is raised by the fact that merchant mills, though

TABLE 4. INVENTORY POSITION OF REPORTING FLOUR MILLS, JUNE 30, YEARS OF WHEAT SHORTAGE AND OF SURPLUS*
(*Million bushels of wheat or wheat equivalent of flour*)

Year	Stocks, Wheat and Flour	Purchase Contracts, Wheat (Futures)	Sales Contracts Flour (Unfilled orders)	Sales Contracts Wheat (Futures)	Excess of Stocks over Flour Sold: Hedging Mills	Excess of Stocks over Flour Sold: Non-hedging Mills
			Years of Shortage			
1925	35.0	.7	25.5 (14)[a]	4.8	4.1	5.5
1926	38.2	11.2	37.5 (23)	10.5	(.6)[b]	1.4
1927	42.8	4.5	33.0 (20)	9.3	4.8	5.0
Average	38.7	5.5	32.0 (19)	8.2	2.8	4.0
			Years of Surplus			
1929	70.8	12.3	55.8 (29)	11.1	(1.2)	16.2
1930	59.7	14.7	67.8 (36)	5.8	(8.9)	.7
1932	70.5	7.8	49.2 (25)	17.8	10.0	11.4
Average	67.0	11.6	57.6 (30)	11.6	.03	9.4

* Data as for Table 2.
[a] Figures in parentheses are the number of days of capacity operation represented by unfilled flour orders.
[b] Unfilled orders in excess of stocks.

so many of them hedge, have not tended strongly to adjust their stocks in accordance with the "carrying charge," as have commercial elevators, but have behaved more like farmers or country mills and elevators in their stock-carrying. Study of their inventory data (Table 4) indicates that even in years of extreme shortage or surplus they continued to follow their normal policy of carrying stocks that approximately cover their unfilled flour orders. In effect, it is flour buyers who primarily determine the level of mill stocks of wheat. Hedging mills cannot be supposed unaware of the opportunities for substantially assured returns from storage in times of surplus. The fact that they have not responded to those opportunities as did storage elevators must mean that the surplus stocks were being carried by the storage elevators for a rate of return too small to be attractive to mill operators.

Conclusions

Some recent attempts to measure the effectiveness of hedging in commodity futures have produced results that are irreconcilable with evidence from business experience with such hedging. In search of explanation of this conflict we have examined representative evidence on the use of commodity futures in what is commonly called hedging. We thus find that the attempted tests of the effectiveness of hedging have gone astray because the prevalent concept of hedging, on which they have been based, is inadequate, and misleading.

Hedging in futures consists of making a *contract to buy or sell on standard terms, established and supervised by a commodity exchange, as a temporary substitute for an intended later contract to buy or sell on other terms.* Then the hedger seeks to make the second purchase or sale, perhaps several months later, on terms that suit him better than those of the standard (futures) contract. When this second contract has been made, the hedger arranges for an offset of the first contract so that delivery is actually made only under the second contract. The effective price, however, is determined primarily by the first contract; following fulfillment of the second contract, the hedger will have received or paid, as the case may be, an amount determined by the price under the first contract, plus or minus a price difference determined at the time the second contract was made, and reflecting any differences between the two contracts in characteristics of the commodity and place of delivery specified.

This definition describes hedging accurately and restrictively, without importing any extraneous and irrelevant implication of intent. The only necessary element of intent, I think, is that of later replacing the futures contract with another contract.[20]

Hedging in futures is done for at least four different reasons: (1) It facilitates *buying and selling decisions.* When hedging is practiced systematically, there is need only to consider whether the price at which a particular purchase or sale can be made is favorable in relation to other current prices; there is no need to consider also whether the absolute level of the price is favorable. (2) It *gives greater freedom for business action.* The freedom most commonly gained is that of buying, for example, when a particular lot of the commodity is available at a *relatively* low price, regardless of its absolute level (this freedom is related to, but

[20] A sale or purchase of futures with intent to make or receive delivery should be regarded as a simple forward sale or purchase, not as hedging; the fact that use is made of a contract form too highly standardized to serve in most commercial forward transactions (a futures contract) does not make it essentially different from any ordinary forward sale or purchase for merchandising purposes.

distinct from, the facilitation of decision mentioned above); often, moreover, the freedom gained is to make a sale or purchase that would not otherwise be possible at what is judged a favorable price level, as when a cotton grower sells futures in advance of harvest, or a textile mill buys futures because cotton prices are judged to be favorable, but the desired qualities of cotton cannot be bought immediately in the spot market.[21] (3) It gives a *reliable basis for conducting storage of commodity surpluses.* The warehousing of surplus commodity stocks is a very uncertain and hazardous business when based on trying to judge when the price is favorable for storage; hedging allows operation on the basis simply of judgment that the spot price is low in relation to a futures price. And (4) hedging *reduces business risks.* There is usually reduction of risk when hedging is done for any of the previous three reasons (though often not under the second reason), but any curtailment of risk may be only an incidental advantage gained, not a primary or even a very important incentive to hedging.

[21] These are transactions which fit the usual definition of hedging only awkwardly if at all. Attempts have been made to show that such hedging reduces risk, but in fact its chief function is to give added freedom in timing the acceptance of a risk that must be taken at some time.

FORAGE-GRAIN SUBSTITUTION: ITS IMPORTANCE IN THE ECONOMICS OF MILK PRODUCTION

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SEVERAL recent articles[1] in this Journal have attributed considerable importance to the determination of economical rates of feeding grain (including other concentrates) and roughage to milk cows. The basic information available is apparently thought to be inadequate as a guide for feeding cows at the most profitable rates. However, the information available on feeding cows is probably more adequate than information on profitable ways of harvesting and storing forage crops.

The purpose of this paper is to test the economic significance of (1) the marginal rates of forage-grain substitution (iso-product type of substitution) and (2) the forage-grain substitution along the stomach capacity line. In the final section the author will point out areas which, in his opinion, are fruitful areas of research in the economics of dairy production.

Testing Forage-Grain Substitution: This analysis is based on the calculations made by Heady.[2] Using his calculations of quantities of hay and grain to be fed to a cow to produce 8,500 pounds of 4% milk in one year, let us apply them to a 20-cow herd, using Wisconsin prices for 1939 and 1946.[3] These represent Wisconsin extremes in milk-grain price ratios during the last 15 years. They also represent a considerable range in the hay-grain price ratios.

In Table 1 intervals are based on changes of 500 pounds of hay equivalent per cow per year, beginning with 11,500 pounds of hay equivalent and 2,157 pounds of grain. The next combination is 11,000 pounds of hay and 2,281 pounds of grain (124 more grain and 500 less hay than the first). Additional quantities of grain increase for each succeeding 500-pound decrease in hay.

The costs of grain and hay (Table 1), at 1939 prices in Wisconsin, are lowest with *2,419* and *2,572* pounds of grain per cow. As the production

* The author is indebted to C. W. Crickman, Lee Day, Sydney Staniforth, and Walter W. Wilcox for helpful suggestions.

[1] Nesius, E. J., *This Journal*, Proceedings number, November 1951; Heady, E. O., *This Journal*, November 1951; and Redman, J. C., *This Journal*, August 1952.

[2] Heady, Earl O., "Utilization of Feed Resources by Dairy Cows," *This Journal*, Part 1, November 1951. Grain from silage was included with the grain and only the forage of the silage was converted to hay equivalent.

[3] The author recognizes the "hybrid" nature of the production function presented by Heady. For a full discussion see Mighell, Ronald L., "What is the Place of the Equal Product Function?", *This Journal*, February 1953. Nevertheless the calculations presented here may serve to show the degree of curvature, the range of price variations and the frequency of extreme price variations necessary to allow much importance to be attached to the marginal rates of forage-grain substitution.

TABLE 1. NET RETURNS ABOVE FEED FOR A 20 COW HERD PRODUCING 8,500 POUNDS OF 4% FAT-CORRECTED MILK, 1939 AND 1946 PRICES[a]

Item	Unit	Inputs and Outputs Per Cow and Per Herd						
Grain per cow	Lb.	2,157	2,281	2,419	2,572	2,744	2,937	3,156
Total milk 8,500×20	Cwt.	1,700	1,700	1,700	1,700	1,700	1,700	1,700
Total grain for 20 cows	Cwt.	431	456	484	514	549	587	631
Hay Equiv. for 20 cows	Ton	115	110	105	100	95	90	85
		Returns and Costs						
(a) Wisconsin 1939 prices								
Milk at $1.11 cwt.	$	1,887	1,887	1,887	1,887	1,887	1,887	1,887
Grain at $1.16 cwt.	$	500	529	561	597	637	681	732
Net returns above grain	$	1,387	1,358	1,326	1,290	1,250	1,206	1,155
Hay at $7.16 per ton	$	823	788	752	716	680	644	609
Net returns above feed	$	564	570	574	574	570	562	546
(b) Wisconsin 1946 prices								
Milk at $3.79 cwt.	$	6,443	6,443	6,443	6,443	6,443	6,443	6,443
Grain at $2.94 cwt.	$	1,268	1,341	1,422	1,512	1,613	1,727	
Net returns above grain	$	5,175	5,102	5,021	4,931	4,830	4,716	
Hay at $14.18 per ton	$	1,631	1,560	1,489	1,418	1,347	1,276	
Net returns above feed	$	3,544	3,542	3,532	3,513	3,483	3,440	

[a] Milk production and feed data based on calculations by Heady, Earl O. "A Production Function and Marginal Rates of Substitution in the Utilization of Feed Resources by Dairy Cows," This Journal, November 1951, p. 493. Basic data from same source as U.S.D.A. Tech. Bul. 815.

of milk is the same for all combinations of feed, both give the same net returns ($574) above costs of feed for the 20-cow herd. The feeding rates both above and below have feed costs $4 higher and, therefore, give net returns of $570. Going one column farther each way shows net returns of $564 and $562. Thus, from 2,157 to 2,937 pounds of grain, the difference in net returns per cow would be only about $0.60, or $12 for a 20-cow herd.

At 1946 Wisconsin prices the least cost for grain and hay, and hence the highest net return above feed ($3,544), comes in the first column. The next column shows a net return of $2 less for the 20-cow herd, and the third column shows a drop of $10. The fourth column, with an increase of 415 pounds more grain per cow than the first, has a decrease in net return of $31 for a 20-cow herd. This amounts to $1.55 decrease in net return per cow. The calculations by Heady were not extended in the other direction where lighter grain feedings would be expected also to result in higher feed costs and lower net returns above feed costs. If this were done, one would expect to find a total range of 800 to 900 pounds in grain feeding per cow, in which the differences in net return above feed costs were insignificant.

In order to test further the effect of various hay-grain price ratios on feed costs and on the net return above all feed costs, a calculated price of $5.60 per ton of hay was used instead of the actual 1939 price of $7.16 a ton. The price of $5.60 is obtained by applying the 1946 hay-grain price ratio of 0.241 to the 1939 grain price. (The lowest hay-grain price ratio since 1939 was 0.218 in 1943.) Applying the hay price of $5.60 per ton and 1939 grain prices gives the highest return above feed cost in the first

column with $743. The net returns in the next four columns would be $742, $738, and $718.

Similarly, if we apply the 1939 hay-grain price ratio of 0.309 to the 1946 grain price, one obtains a price for hay of $18.17 instead of $14.18, the actual 1946 price. (The highest hay-grain price ratio since 1939 was 0.355 in 1949). Appling the hay price of $18.17 per ton and 1946 grain prices gives the highest net return above feed cost in the third and fourth columns $3,113 and $3,114. In the second and fifth columns the net returns would be $3,103 and $3,104.

The possibility of increasing net returns on farms by feeding according to the marginal rates of substitution seems even more remote when one considers also the additional labor needed to weigh out daily to each cow the limited quantities of hay, silage and grain determined by the experiment and to provide the additional equipment needed to protect the limited supply of hay and silage of each cow from her greedy neighbors.

Forage-Grain Substitution at the Stomach Capacity Line: The usual method of feeding milk cows is to provide all of the roughage (forage) that each cow will eat at whatever level of grain feeding the dairyman judges will be most profitable at the prevailing prices of grain and milk. The supply of roughage harvested in dairy areas is usually adjusted roughly to the quantity needed, considering the usual rate of grain feeding.

The quantities of roughage eaten by cows with varying quantities of grain fed, and the milk produced at the various rates of feeding shown in Table 2 A and B are based on U.S.D.A. Technical Bulletin 815, page 72 and page 80, respectively.[4] The prices used are the same as in Table 1.

The main point shown in both A and B of Table 2 as in Table 1, and in Figure 1 is the small difference in the net returns above feed costs in the groups that were fed different quantities of grain within the usual range, even at the extreme limits experienced with the milk-grain price ratios. Thus in Table 2 A at 1939 prices, the least favorable milk-grain price ratio, the net returns for milk above feed costs differ very little whether the cows are fed an average of 450 or 1,800 pounds of grain. The net returns above feed are:

$552 at 450 pounds
$567 at 900 pounds
$566 at 1,350 pounds
$544 at 1,800 pounds

[4] Interpolations were made from curves for milk production and hay equivalent eaten similar to those shown on page 72 of the bulletin. Thus the production of milk and the hay consumed are obtained for each 450 pound change in grain. This makes the calculations comparable to the basic data in U.S.D.A. Technical Bulletin 815, page 80.

At higher and lower rates of feeding the net returns drop more rapidly.

With the 1946 prices, which were more favorable for heavy feeding of grain, the highest net return above feed ($3,347) comes at 1,350 pounds of grain per cow. Going up to 1,800 pounds of grain per cow would have lowered the net returns for the 20-cow herd by $12; and feeding only 900

TABLE 2. NET RETURNS ABOVE FEED FOR A 20-COW HERD AT DIFFERENT LEVELS OF GRAIN FEEDING, 1939 AND 1946 PRICES

Item	Unit	Inputs and outputs per cow and per herd[a]						
A.—Herd with average capacity per cow of 7,200 pounds of 4% fat-corrected milk.								
Grain per cow	Lbs.	0	450	900	1,350	1,800	2,250	2,700
Milk per cow	Lbs.	6,120	6,700	7,170	7,540	7,815	8,015	8,180
Total milk produced	Cwt.	1,224	1,340	1,434	1,508	1,563	1,603	1,636
Total grain for 20 cows	Cwt.	0	90	180	270	360	450	540
Total hay for 20 cows[b]	Tons	117	116	114	111	108	105	102
		Returns and Costs						
(a) Wisconsin 1939 prices								
Milk at $1.11 cwt.	$	1,359	1,487	1,592	1,674	1,735	1,779	1,816
Grain at $1.16 cwt.	$	0	104	209	313	418	522	626
Net return above grain	$	1,359	1,383	1,383	1,361	1,317	1,257	1,190
Hay at $7.16 per ton	$	838	831	816	795	773	752	730
Net return above feed	$	521	552	567	566	544	505	460
(b) Wisconsin 1946 prices								
Milk at $3.79 cwt.	$	4,639	5,079	5,435	5,715	5,924	6,075	6,200
Grain at $2.94 cwt.	$	0	265	529	794	1,058	1,323	1,588
Net return above grain	$	4,639	4,814	4,906	4,921	4,866	4,752	4,612
Hay at $14.18 per ton	$	1,659	1,645	1,616	1,574	1,531	1,489	1,446
Net return above feed	$	2,980	3,169	3,290	3,347	3,335	3,263	3,166

Item	Unit	Inputs and outputs per cow per herd.[a]						
B.—Herd with average capacity per cow of 8,900 pounds of 4% fat-corrected milk.								
Grain per cow	Lbs.	0	450	900	1,350	1,800	2,250	2,700
Milk per cow	Lbs.	6,438	7,020	7,517	7,947	8,317	8,639	8,915
Total milk produced	Cwt.	1,288	1,404	1,503	1,589	1,663	1,728	1,783
Total grain for 20 cows	Cwt.	0	90	180	270	360	450	540
Total hay for 20 cows[b]	Tons	113	110	107	104	101	98	95
		Returns and Costs						
(a) Wisconsin 1939 prices								
Milk at $1.11 cwt.	$	1,429	1,558	1,669	1,764	1,846	1,918	1,979
Grain at $1.16 cwt.	$	0	104	209	313	418	522	626
Net return above grain	$	1,429	1,454	1,460	1,451	1,428	1,396	1,353
Hay at $7.16 per ton	$	812	790	770	748	726	703	680
Net return above feed	$	617	664	690	703	702	693	673
(b) Wisconsin 1946 prices								
Milk at $3.79 cwt.	$	4,880	5,321	5,698	6,024	6,304	6,548	6,758
Grain at $2.94 cwt.	$	0	265	529	794	1,058	1,323	1,588
Net return above grain	$	4,880	5,056	5,169	5,230	5,246	5,225	5,170
Hay at $14.18 per ton	$	1,608	1,565	1,526	1,480	1,438	1,392	1,347
Net return above feed	$	3,272	3,491	3,643	3,750	3,808	3,833	3,823

[a] Milk production and feed data based on U.S.D.A. Technical Bul. 815. A.—p. 70, B.—p. 80.
[b] Total hay equivalent.

pounds would have lowered them by $57. Apparently there would have been a slight advantage in feeding about 100 pounds more than the 1,350 pounds of grain per cow per year.

When cows with the capacity to produce 8,900 pounds of 4 percent fat-corrected milk are fed according to the feeding standard, they can use profitably 500 to 800 more pounds of grain (see Table 2 B) than cows with a capacity of only 7,200 pounds of 4 percent milk shown in Table 2 A. Thus in Table 2 B with 1939 prices of milk, grain, and hay, the highest net return above feed for a 20-cow herd comes by feeding between

1,350 and 1,800 (about 1,600) pounds of grain per cow. However, feeding only 900 pounds per cow reduces the net returns for the 20-cow herd only $13 below the 1,350 pound grain feeding rate, and increasing it to 2,250 pounds reduces it only $9 below the 1,800 pound grain feeding rate.

With 1946 prices of milk and feed the highest net return above feed ($3,833) is obtained by feeding 2,250 pounds of grain per cow. Increasing the grain to 2,700 pounds per cow would lower the net return $10. The general affect of the various grain feeding rates on net returns above feed can be readily seen in Figure 1. The surprising thing is the wide range in feeding grain in which there is so little difference in net returns. This applies to low as well as to high-capacity cows.

TABLE 3. NET RETURNS ABOVE FEED FOR A 20-COW HERD OF HIGH CAPACITY COWS AT DIFFERENT LEVELS OF GRAIN FEEDING WITH EXCELLENT QUALITY ROUGHAGE, 1939 AND 1946 PRICES[a]

Item	Unit	Inputs and outputs per cow and per herd						
Grain per cow	Lb.	0	450	900	1,350	1,800	2,250	2,700
Milk per cow	Lb.	8,388	8,790	9,185	9,490	9,745	9,950	10,125
Total milk produced	Cwt.	1,678	1,758	1,837	1,898	1,949	1,990	2,025
Total grain fed to 20 cows	Cwt.	0	90	180	270	360	450	540
Hay Equiv. fed to 20 cows	Ton	118	115	112	109	106	103	99
		Returns and Costs						
(a) Wisconsin 1939 prices								
Milk at $1.11 cwt.	$	1,862	1,951	2,039	2,107	2,163	2,209	2,248
Grain at $1.16 cwt.	$	0	104	209	313	418	522	626
Net returns above grain	$	1,862	1,847	1,830	1,794	1,745	1,687	1,622
Hay at $7.16 per ton	$	845	823	802	780	758	735	712
Net return above feed	$	981	1,024	1,028	1,014	987	952	910
(b) Wisconsin 1946 prices								
Milk at $3.79 cwt.	$	6,358	6,663	6,962	7,193	7,397	7,542	7,675
Grain at $2.94 cwt.	$	0	265	529	794	1,058	1,323	1,588
Net return above grain	$	6,358	6,398	6,433	6,399	6,329	6,219	6,087
Hay at $14.18 per ton	$	1,673	1,631	1,588	1,546	1,500	1,455	1,409
Net return above feed	$	4,685	4,767	4,845	4,853	4,829	4,764	4,678

[a] N. J. Agr. Exp. Sta. reported by C. B. Bender, in *Hoard's Dairyman* Apr. 25, 1951; and Geo. M. Werner, "Why Good Roughage," Mimeo. Report, Dairy Husbandry Department, University of Wisconsin.

The New Jersey Experiment Station[5] fed three lots of cows at different levels over a period of five years. Excellent roughage was fed and the cows appeared to have a lot of capacity. One lot was fed all roughage, a second lot 1 pound grain to 6 pounds of milk and the third lot 1 pound grain to 3 pounds of milk. Then input and output curves are drawn and readings taken at 450 pound intervals of grain feeding, the results shown in Table 3 are obtained. Quantities of feed in Table 3 are only for the 305 day milking period, whereas those in Table 2 are for 365 days.

Production per cow on roughage alone was about 2,000 pounds more than in Table 2. The highest return above feed at Wisconsin prices for 1939 came at 900 pounds of grain per cow. But at 450 pounds of grain per cow the return above feed for a 20-cow herd was only $4 less and at 1,350 pounds of grain, the net return was only $14 less than at 900 pounds

[5] See Table 3 footnote.

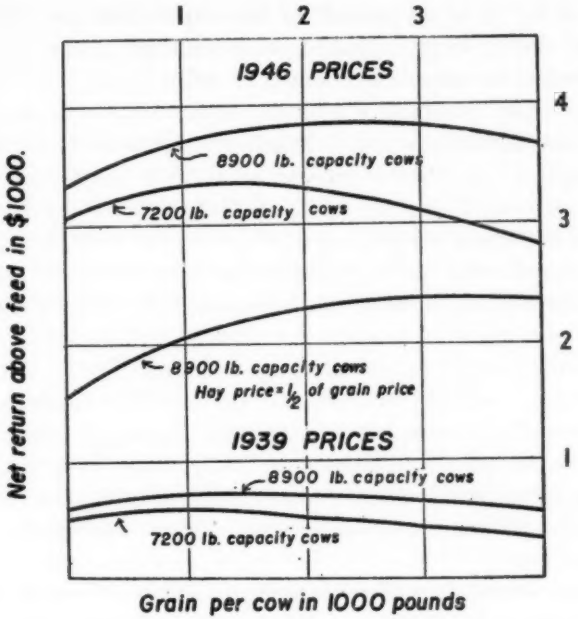

FIG. 1

of grain. With 1946 prices in Wisconsin the highest return above feed comes at 1,350 pounds of grain per cow and falls slightly faster on either side compared with the 1939 prices.

Charging the roughage at a price equal to half the price of grain moves the area of highest return above feed costs to a few hundred pounds more grain but has little effect on the range of indifference in net returns above costs of all feed.

Hay and Grain Prices in Wisconsin: Since 1930 the range in loose hay prices per ton, as reported in the *Wisconsin Crop and Livestock Reporter,* has been from $7.16 in 1939 to $21.29 in 1948. There has been little variation in hay prices between the various crop reporting districts in Wisconsin. The value of the dairy grain ration has varied from $14.49 a ton in 1932 to $73.60 in 1948. In 17 of the last 22 years, hay prices have been between 0.2 to 0.4 of the value of the dairy grain ration. Since 1940 the average hay-grain price ratio has been 0.274. According to the total digestible nutrient content of hay and grain, the ratio is 0.67. This is generally considered to be a basis which over-values hay. A ratio of 0.57 is more nearly correct for good hay[6] and for average hay a ratio of 0.5 is about right, within the ordinary range of roughage (forage) and grain

[6] Morrison, F. B., *Feeds and Feeding,* 21st Ed., p. 679.

feeding, that is, 1½ to 2¾ pounds of hay equivalent per 100 pounds of live weight daily,[7] supplemented with enough grain to supply the nutrients needed for specified amounts of milk.

Hay is a bulky product. Preparing it for market is expensive and shipping it any distance is costly. Practically all areas in Wisconsin grow enough roughage for their own use so definite market prices are not readily established. These are some of the reasons why hay and other roughage on the farm, except in case of occasional deficits, may be undervalued compared with their feeding value. The point we are concerned with here is that if hay is valued at its feeding value (about one-half of the grain price) the point of highest net return is shifted to heavier grain feeding and the range of indifference is widened slightly. (See Figure 1.)

One reason for wanting to feed cows on as much roughage as possible is the low cost of the roughage. Cows can produce more milk on good roughage than on poor roughage. But if costs must be greatly increased in order to produce good roughage, the most profitable rate of feeding will be moved toward heavier grain feeding. When more grain is fed, less roughage is eaten.

The interest shown in soil conservation is likely to result in an abundance of roughage in Wisconsin. The main outlet for this roughage in the state will be as a feed for dairy cattle. Ordinarily in Wisconsin, the quality of the roughage and the milk-grain price are the main determinants of how much roughage cows will consume. The price of hay is important only in case of a drought that would mean shipping in hay. The average hay yields in Wisconsin in 1930-34 dropped further below normal than in any five-year period since 1866, when annual crop estimates began. Prices of hay were unusually high during 1930-34 mainly because of the low yields.

Grain Feeding and Milk Production in Wisconsin, 1930-51: Data on the ratio of grain fed and production of milk per cow in Wisconsin in 1930-51 show that from 1930-39 the amounts of grain fed per cow varied from about 800 to 1,200 pounds. In relation to milk production per cow, one pound of grain was fed per 4.6 to 6.4 pounds of milk. During this 10-year period the milk-grain price ratio (using the farm price of milk) averaged 0.94. From 1940-49 the milk-grain price ratio was generally more favorable to milk production, averaging 1.13. Grain feeding per cow increased from 1,261 pounds in 1940 to 2,011 in 1949. The milk-grain price ratio was 1.29 in 1946 and dropped to 1.03 in 1949. Grain feeding, however, increased more than 100 pounds from 1946 to 1949 and milk production per cow increased 500 pounds according to the best estimates. Since 1943 the rate of grain feeding in relation to milk production

[7] *Ibid.*, p. 1187.

increased gradually and has varied from 1 to 3.6 to 1 to 3.3. Apparently farmers had become accustomed to heavier and higher production and were continuing nearly the same rate of grain feeding regardless of the fact that since 1946 the milk-grain price ratio was 1.01, 1.10, 1.03, 1.02, and 1.12, respectively, for each consecutive year beginning with 1947.

The relatively heavy grain feeding in relation to milk production per cow in Wisconsin during recent years compared with the experiment station herds is probably due to poorer roughage and less expert management on the average farm. The feeding of grain on farms is not so heavy in terms of pounds per cow but in recent years it has been fairly high in relation to the milk produced.

Feeding Standards and Practices[8]

Milk cows give the feeder the unusual opportunity of ascertaining the principal output (milk), at least twice a day, and thus the basis for adjusting the feed more quickly to production than with most other classes of livestock. Furthermore, milk cows are the only class of farm animals, except horses, that have their grain fed to them individually. Usually progressive dairymen feed it roughly according to each cow's milk production. As a rule roughage is not fed to cows individually. Even in the experimental feeding at 10 experiment stations to obtain the data presented in U.S.D.A. Technical Bulletin 815, additional equipment had to be added to the mangers to insure individual feeding of roughage. More labor was also required.

Thus while fattening cattle are fed entirely in groups according to live weight, and hogs are generally self-fed, milk cows get more individual attention both as to input and output. Production and consumption of feed vary more among milk cows than among hogs or even among fattening cattle. Also the individual variations can be more accurately measured. This makes it possible to get more out of feed by adjusting the input of grain for each cow to the milk produced by that cow. The condition of each cow must be considered also.

A great deal of research work has been done to determine the nutrients needed for maintenance of cows of different weights and for producing a pound of milk of different butterfat tests. Many thousands of records of individual cows show that some milk cows have the capacity to produce two to three times more milk (fat corrected) than others. Skillful dairymen will give each cow the opportunity of proving her ability to produce by supplying the needed nutrients. If the cow does not respond, the grain ration is reduced in due time, to the needs of her actual production.

[8] This is included because I have found some misunderstanding of feeding standards and feeding practices among agricultural economists.

Long before U.S.D.A. Technical Bulletin 815 was published, dairymen and researchers in nutrition knew that a lot of feed was wasted if one attempts to feed a 20-pound-capacity cow enough to make her produce 40 pounds of milk daily. The study established the rate of diminishing output more definitely. But the feeding standards, or the tables for grain feeding and rules of thumb which are approximations to the feeding standards, enable dairymen to adjust the input of feed quickly to the capacity of the cow and thus reduce feed waste.

The usual explanation for using feeding standards for a cow is like this: "The amount of nutrients required for a cow producing a given amount of milk which contains a certain percentage of fat are found as follows: Add together the maintenance requirements for a cow of the particular live weight and the requirements for producing the given amount of milk."[9]

This does not imply that if the production ration were doubled the production of milk would be doubled. No experienced dairyman would expect this unless it were evident that the cow had been fed at only half of her capacity before.

Under usual farm conditions cows testing 3.5 to 4.0 percent milk fat are fed 1 pound of grain to 3.5-6.0 pounds of milk and what hay and silage they will clean up. If hay is plentiful and only fair in quality, the cows may be fed more of it and they will pick out the choicer parts and reject the poorest. The actual quantities eaten by each cow can be estimated only roughly, if it is done at all. The nutrient content of roughages varies widely from the average composition given in tables on nutrients in feeds. So, after getting the best information available, or that is likely to become available, on feeds and feed requirements a lot is left to the judgment of the dairyman. However, as shown in Tables 2 and 3, there is a considerable range in grain feeding in which the net returns above feed costs are not greatly affected.

More Important Phases of Dairy Farming

A number of questions about dairy farming on which farmers would like information seem to the writer of greater economic importance than determining grain-forage iso-product contours. All of these questions center around the general problem of how the forage crops can be best fitted in with the whole farm business. More specifically, they are concerned with seed mixtures, stage at which to cut, harvesting, and storage.

A few examples of farmer experience will make these problems more

[9] Morrison, F. B., *op. cit.*, p. 1145.

concrete. Rex Paterson,[10] an English farmer, has been putting up several thousand tons of grass silage each year. He cuts the grass at a very immature stage, wilts it, and puts it up long into trench silos or stacks in the fields with buckrakes attached to the rear of tractors. No forage harvester or silage cutter is used. Although his land is underlain with chalk, he prefers grass to alfalfa because he can cut it earlier without damage to the stand. A large-scale dairy farmer in Wisconsin is considering a 100-percent grass mixture for the same reason. He is also using trench silos, but uses forage harvesters.

The gas-tight silo with the unloader at the bottom offers possibilities of saving more nearly 100 percent of the forage crops with a somewhat lower than usual water content. For putting up dry hay the hay crushers and mow driers, with or without artificial heat, compete for the dairyman's dollar.

Research work at Beltsville, Md. and Cornell University gives useful information on grass silage compared with mow drying and field drying for a number of seasons. Many farmers are trying out these new methods. Their experiences require careful analysis as it takes time to perfect new methods that affect field crops and to adjust livestock numbers to get full advantage of any changes in the feed supply.

The difference in capital investment for machinery and silo on a 20 to 30-cow dairy farm where a forage chopper and a gas-tight silo are used, compared with Rex Paterson's buckrake and trench silo, may be up to $10,000. If the annual cost is estimated at 10 percent of the investment it amounts to $1,000. Of course, there is greater loss of nutrients in a trench silo than in a gastight silo but Rex Paterson has cut his loss to a very low figure. Loss in storage on the farm needs further study.

The difference in harvesting equipment may amount to $5,000. The annual cost on this is likely to be above 10 percent of the cost now, so an estimate of $500 difference annually for expenses of special harvesting equipment would be conservative.

These are only a few examples of practical problems that are in need of analysis by the research economist.

[10] Rex Paterson was present at the International Conference of Agricultural Economists at East Lansing, Michigan and at the annual meeting of the American Farm Economic Association at Urbana, Illinois, in August, 1952, and was written up in the April 25, 1951 issue of *Hoard's Dairyman*.

PROPER PLANNING REDUCES RESEARCH ERRORS*

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Introduction

THIS paper presents some suggestions for reducing research errors in farm economics research projects. These suggestions are based on the experience of the author as a statistical consultant for a number of regional and state projects over the past six years. It will be assumed that research errors include any feature of a research project which produces an answer different from the true or population value. In addition to the usual sampling, experimental, measurement and technique errors, biases (either because of incorrect planning or analysis), incorrect specifications and inadequate data will be considered as research errors.

A brief discussion of four of the above-mentioned projects will be used to set the stage. All of these were sample surveys, but certain aspects of experimental design will be pointed out. One regional survey was set up to estimate certain characteristics of farm households. A sample of farms was selected from five states to represent three subregions of the Southeast. Almost a year later, two more states decided to participate in the program. At this time, the author was asked to draw up a sample to represent six of the seven subregions of the Southeast—all except the Gulf area. Only the two new states would have represented the three new subregions, except that some outside funds were found to enable one of the original five to secure more schedules. The other four states did not have the funds to secure more schedules. As a result, the sample could not be adjusted so that the same sampling rate was applicable to each of the six subregions. The sampling rates (in percents) were: .27, .41, .30, .30, .32, and .39. In order to obtain an unbiased total for any characteristic over the whole Southeast, the sample totals in each subregion should be weighted inversely to the sampling rate in that subregion. The over-all household average could be obtained by dividing this weighted total by a similarly weighted total of the sample numbers of households in the subregions. Such a weighting procedure would have increased the computing time so much that only a few of the desired characteristic averages could have been computed with the funds available. This was particularly true for this survey because most of the averages were percentages of the total sample falling in given categories; an unweighted total could be obtained by the use of a card sorter with a counter. Weighting would have

* Presented at annual meeting of Marketing Section of Association of Southern Agricultural Workers, New Orleans, Feb. 10, 1953.

required separate sorts in each subregion and then a computation to secure the weighted total. A spot check was made for some items to determine the amount of bias when unweighted means were used; some means were biased by as much as 10% and others by less than 1%.

In another Southeastern survey, four states participated. A sample of rural areas was drawn to provide sufficient schedules for the survey. Unfortunately different enumerators were used in each state, and each state had a different idea of what constituted an eligible farmer. One state had run a similar survey earlier and may have used some of these schedules instead of visiting new areas. An effort is now being made to salvage the information already secured, but this is a rather thankless task.

Two North Carolina surveys will be discussed to demonstrate that planning is as important in local as in regional surveys. One survey was designed to estimate the average yield of corn in 1949. A sample of corn was taken for every 10 acres of corn for grain in selected areas of each county in the state. This procedure was easy to explain to enumerators, and the resultant estimate of corn yield was simple and highly efficient. However, after the sampling plan was devised, it was decided to obtain information on hay yields and on farming practices. Because of the special sample design, estimates of these other characteristics were much more complicated and less efficient than that of corn yield.

A survey was designed in 1950 to estimate the average price received for slaughter cattle at spring auctions. It was desired to obtain information on the influence of the following factors on prices: Region of state (Mountain, Piedmont, Coastal Plains), Size of market (Large, Medium, Small), Breed (Beef, Dairy, Mixed), Weight and Live Grade. Three graders were supposed to do the grading, with each selected market to be visited in three successive weeks. Since only one auction could be visited per day, only 15 auctions could be contacted: 2 large, 1 medium and 2 small auctions in each of the three regions. It was necessary to select the sample auctions so that a given grader could visit a different one each day. The sale dates of each auction were obtained, and the five auctions in each region were selected so that each had a different sale date. The grading plan is given below, where the graders are indicated as A, B and C.

		Regions	
Weeks	*Mountain*	*Piedmont*	*Coastal Plains*
1	C	A	B
2	A	B	C
3	B	C	A

Since every region would have 2 large, 1 medium, and 2 small markets, the design was balanced as regards size and region comparisons for each

week and grader. Admittedly, one would not have balance as regards the other three factors, but at least partial balance would have been obtained. It was planned to repeat this survey in the fall, so that region and size effects would have been balanced for the two seasons.

The types of auctions actually visited were as follows:

	Mountain		*Piedmont*		*Coastal Plains*	
	Spring	Fall	Spring	Fall	Spring	Fall
Large	2	2	1	0	1	0
Medium	0	0	2	4	0	1
Small	2	2	2	2	4	6
Total	4	4	5	6	5	7

Why this departure from the balanced plan? Two large auctions were reclassified after the survey started, one as medium and one small; two large ones were later reclassified as medium for the fall survey. Three medium auctions were reclassified as small after the survey started but one new medium auction was added. Two small markets were never visited. Then one medium and two small markets were added to the fall survey.

These experiences illustrate the need for better planning. Specific suggestions for reducing research errors are presented below under two major categories: (a) Administrative Procedures and (b) Sampling Techniques. A more detailed discussion follows on the use of experimental design in farm economics research.

Reducing Research Errors at the Administrative Level

(a) Delineate the problem to be investigated and define the universe before starting the research project. In the final analysis, the participants often want to describe a different population from that actually sampled. Be sure that the survey or experiment includes all the topics and measurements about which references are to be made in the final report. The units of measurement need to be decided upon.

(b) Obtain properly trained personnel to handle the experiment or survey, such as interviewers, laboratory technicians and supervisors.

(c) Outline the methods of analysis before the data are collected. The outline should include a list of all tables, such as factor means and cross-tabulations. This may provide a clue as to the proper experimental or sampling design to make the analysis simple. Allocate sufficient funds for analysis. The experimenter should decide whether he will need costly computing equipment; if computers are needed, it is necessary to know that they will be available. A superior sampling design from the point of view of sampling error may be cast aside for a less efficient design which will produce self-

weighting data. The need for self-weighting data is especially important in regional projects, where part or all of the analyses may be carried on at several locations.

(d) Develop a method of pooling resources in regional research. If there is no well coordinated plan for allocating the funds, the sample may become unbalanced because some states have more funds than others.

(e) Put the regional plan ahead of separate state interests. Often the experiment or sample will become unbalanced because an individual wants to publish a state bulletin about that part of the regional project carried on in his own state. As a result each state wants about the same number of schedules, regardless of the proportionate number it should obtain. This results in setting up fixed sample numbers for each state, often a difficult objective with area sampling.

(f) Have someone associated with each research project who is versed in survey and design methods. This person needs to be provided with the time to make intensive investigations of the results of surveys on such points as sampling errors and costs.

Reducing Research Errors by the Use of Modern Sampling Techniques

(a) Be sure the sample represents the population defined above. Guard against taking a sample from a small area and then stating it represents a wider area in the final report. But in this same connection, it is the duty of the advisor on sampling to indicate how reliable his sample result can be expected to be. If the sample must be so thinly scattered that it will not represent the desired population with some reasonable accuracy, the sampler should not be afraid to advise the research man to restrict his inferences to a smaller population. A good estimate for one segment of the population may be better than a very poor estimate of the whole population. This is particularly true in exploratory research.

(b) Consider the following points in selecting the sample:

(i) Type of sample (sometimes called the frame), e.g. a list sample, an area sample (such as the Master Sample of Agriculture or city blocks), a route sample, or a quota sample (such as used in many public opinion polls).

(ii) Sampling unit (depends on frame), e.g. a farm, a group of farms, a household, a city block, a market, or an auction.

(iii) Method of sampling, e.g. random, stratified, or systematic.

(iv) Sub-sampling.

(v) Size of sample, which depends on the money and personnel

week and grader. Admittedly, one would not have balance as regards the other three factors, but at least partial balance would have been obtained. It was planned to repeat this survey in the fall, so that region and size effects would have been balanced for the two seasons.

The types of auctions actually visited were as follows:

	Mountain		*Piedmont*		*Coastal Plains*	
	Spring	Fall	Spring	Fall	Spring	Fall
Large	2	2	1	0	1	0
Medium	0	0	2	4	0	1
Small	2	2	2	2	4	6
Total	4	4	5	6	5	7

Why this departure from the balanced plan? Two large auctions were reclassified after the survey started, one as medium and one small; two large ones were later reclassified as medium for the fall survey. Three medium auctions were reclassified as small after the survey started but one new medium auction was added. Two small markets were never visited. Then one medium and two small markets were added to the fall survey.

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(a) Delineate the problem to be investigated and define the universe before starting the research project. In the final analysis, the participants often want to describe a different population from that actually sampled. Be sure that the survey or experiment includes all the topics and measurements about which references are to be made in the final report. The units of measurement need to be decided upon.

(b) Obtain properly trained personnel to handle the experiment or survey, such as interviewers, laboratory technicians and supervisors.

(c) Outline the methods of analysis before the data are collected. The outline should include a list of all tables, such as factor means and cross-tabulations. This may provide a clue as to the proper experimental or sampling design to make the analysis simple. Allocate sufficient funds for analysis. The experimenter should decide whether he will need costly computing equipment; if computers are needed, it is necessary to know that they will be available. A superior sampling design from the point of view of sampling error may be cast aside for a less efficient design which will produce self-

weighting data. The need for self-weighting data is especially important in regional projects, where part or all of the analyses may be carried on at several locations.

(d) Develop a method of pooling resources in regional research. If there is no well coordinated plan for allocating the funds, the sample may become unbalanced because some states have more funds than others.

(e) Put the regional plan ahead of separate state interests. Often the experiment or sample will become unbalanced because an individual wants to publish a state bulletin about that part of the regional project carried on in his own state. As a result each state wants about the same number of schedules, regardless of the proportionate number it should obtain. This results in setting up fixed sample numbers for each state, often a difficult objective with area sampling.

(f) Have someone associated with each research project who is versed in survey and design methods. This person needs to be provided with the time to make intensive investigations of the results of surveys on such points as sampling errors and costs.

Reducing Research Errors by the Use of Modern Sampling Techniques

(a) Be sure the sample represents the population defined above. Guard against taking a sample from a small area and then stating it represents a wider area in the final report. But in this same connection, it is the duty of the advisor on sampling to indicate how reliable his sample result can be expected to be. If the sample must be so thinly scattered that it will not represent the desired population with some reasonable accuracy, the sampler should not be afraid to advise the research man to restrict his inferences to a smaller population. A good estimate for one segment of the population may be better than a very poor estimate of the whole population. This is particularly true in exploratory research.

(b) Consider the following points in selecting the sample:

(i) Type of sample (sometimes called the frame), e.g. a list sample, an area sample (such as the Master Sample of Agriculture or city blocks), a route sample, or a quota sample (such as used in many public opinion polls).

(ii) Sampling unit (depends on frame), e.g. a farm, a group of farms, a household, a city block, a market, or an auction.

(iii) Method of sampling, e.g. random, stratified, or systematic.

(iv) Sub-sampling.

(v) Size of sample, which depends on the money and personnel

available and the accuracy desired.

(vi) In connection with the sample size, will it be necessary to estimate proportions or means for fine breakdowns? For example if the data are to be classified on the basis of four factors, each with 3 classes, there will be a total of 81 factor combinations. The sample size will have to be quite large if any degree of accuracy is to be obtained for the averages for each of these combinations. Even if only 2-way tables are desired, there will be six tables, each with 9 cells.

(c) Pretest the questionnaire to see that the questions will obtain the desired information. One must weigh the need to obtain all the necessary information against the possible inefficiency of long questionnaires.

(d) Can the information or part of it be secured by mail or telephone or must a more expensive personal interview be used? The answer to this question often may determine if the survey can be conducted at all. If good information cannot be obtained by mail or if the expected response is low, the survey may have to be abandoned because of the cost of personal interviews. A preliminary mailed questionnaire might be used to indicate the possible response.

(e) Plan surveys so that simple analyses of sampling errors can be made.

(f) Collect data on the costs of performing the various steps in the survey.

The Use of Experimental Designs in Farm Economics Research

Finally some remarks are appropriate on the use of a much neglected tool in farm economics research: *experimental design*. For example, many surveys are conducted to determine the influence of various factors on prices. The North Carolina auction survey was one of these. Such surveys are called *analytical surveys* and require different treatment from the usual sampling theory for estimating population totals or means. Other surveys which combine these two purposes are even more difficult to handle. In this section only analytical methods will be discussed.

An artificial example has been prepared to show how research error can be reduced if the population can be identified in advance so as to permit the use of a balanced experimental design. It will be assumed that the economist wants to know the influence of three factors, A, B, and C, on the price of some product. Each factor is divided into two classes, so that there is a total of 8 possible cells. A sample of 200 is assumed to be selected from this population, cell frequencies as shown in parentheses in Table 1. Population average prices are presented for each cell. The prices were constructed by setting the price for the $A_1B_1C_1$ cell equal to 15, and adding 10 for a switch to A_2, 20 for B_2 and 40 for C_2.

TABLE 1. POPULATION PRICES AND SAMPLE FREQUENCIES IN A 3-FACTOR PROBLEM (NO INTERACTION)

	A_1		A_2		Unwtd. Mean
	B_1	B_2	B_1	B_2	
C_1	15 (5)	35 (60)	25 (25)	45 (10)	30 (100)
C_2	55 (10)	75 (25)	65 (60)	85 (5)	70 (100)
Unwtd. Mean	45 (100)		55 (100)		

The sample totals of prices for each class in Table 1 are:

$A_1 = 4600$ $B_1 = 5150$ $C_1 = 3250$
$A_2 = 5400$ $B_2 = 4850$ $C_2 = 6750$

The unweighted B means are 40 and 60.

Let us examine the average results of using various computing techniques to estimate the differences, d_a, d_b, d_c, between the mean prices for the two classes of each factor. These differences are computed on the basis of the population means. Sample results would fluctuate because of the sampling variability; hence, the statements below are average results.

(a) *Usual weighted method.* Compute totals in each cell and add all cells for each class. For example, the C_1 total is $75 + 2100 + 625 + 450 = 3250$. The average mean differences are $d_a = 8$, $d_b = -3$, $d_c = 35$. Note that the *a* and *c* differences are slightly too small (should be 10 and 40) and that the *b* difference is in the wrong direction (-3 instead of $+20$). This bias of the estimates is typical of the weighted analysis, if the cell frequencies are decidedly unequal.

(b) *An unweighted analysis.* Average only the cell means. This method is unbiased but each difference may have a large sampling variance. In the above example, this variance is

$$\frac{1}{16}\left(\sum \frac{1}{n_i}\right)\sigma^2 = .045\,\sigma^2,$$

where the n_i are the 8 cell frequencies and σ^2 is the average variance within cells. Hence the standard error of any mean difference is $.21\,\sigma$.

(c) *Least squares analysis.* This method is also unbiased and has somewhat lower variances than the unweighted analysis. The computing details are given in Table 2.

The variances are $.039\,\sigma^2$, $.042\,\sigma^2$, and $.024\,\sigma^2$ for d_a, d_b, and d_c, respectively. There is much more computing when the least squares instead of the unweighted analysis is used. The reduction in variance is often so small that this added computing is not profitable.

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TABLE 2. ABBREVIATED DOOLITTLE METHOD OF COMPUTING FOR THE METHOD OF LEAST SQUARES[1]

Original Equations

Equation	Mean	A_2	B_2	C_2	Total Price
Mean	200	100	100	100	10,000
A_2		100	15	65	5,400
B_2			100	30	4,850
C_2				100	6,750

Forward Solution

Mean	A_2	B_2	C_2	Total Price
200	100	100	100	10,000
1	.5	.5	.5	50
	50	−35	15	400
	1	−.7	.3	8
		25.5	−9.5	130
		1	−19/51	260/51
			2140/51	85,600/51
			1	$40=d_c$

$d_b=[260+40\ (19)]/51=20$; $d_a=8+.7\ (20)-.3\ (40)=10$.

If the population could be stratified in advance and 25 observations selected for each cell (giving the same total sample of 200), all methods of analysis would produce the same results. The variance of each mean difference would be .02 σ^2, less than one-half that of the unweighted mean difference with the disproportionate cell frequencies. Admittedly it is not possible to stratify in advance in most surveys, but one should do so if possible. And in many cases the sample can be drawn to reduce the disproportionacy so that an unweighted analysis would not be too inefficient.[2]

One disturbing feature of tabulated data is that the cell averages do not always follow the simple additive law, which was used in forming the cell averages in Table 1. Departures from additivity are often described as *interactions*. One of the merits of a balanced design is the ease

[1] This method is described in detail, with examples, in Anderson, R. L. and Bancroft, T. A. *Statistical Theory in Research*, McGraw-Hill Book Co., New York, 1952.

[2] If the experimenter also wants to estimate the population total or mean, he must weight the individual cell means proportional to the population frequencies. As a result, the population total or mean is estimated less efficiently than if a proportional sample were drawn. In the artificial example, the variance of the estimated population total or mean would be 74% greater for the equalized sample (25 per cell) than for a proportional sample (assuming the sample frequencies in Table 1 are proportional to the population frequencies). Hence if factor differences and the population mean are of equal importance, the equalized sample may not be useful, even if it could be drawn.

TABLE 3. WEIGHTED AND UNWEIGHTED MEANS FOR PRICE DATA WITH A NEGATIVE (AC) INTERACTION

(i) *Weighted means.*

	A_1	A_2	B_1	B_2		A_1	A_2
C_1	33.46	30.71	23.33	36.43	B_1	41.67	39.12
C_2	69.29	46.54	46.43	73.33	B_2	46.77	51.67

(ii) *Unweighted means.*

	A_1	A_2	B_1	B_2		A_1	A_2
C_1	25	35	20	40	B_1	35	35
C_2	65	55	50	70	B_2	55	55

of detecting the presence of interactions. Hence, it is desirable to study how the various computing schemes would handle this problem, when the frequencies follow the unbalanced plan of Table 1.

An (AC) interaction was introduced by reducing the means for the (A_2C_2) combinations in Table 1 by 20, i.e. $(A_2B_1C_2) = 45$ and $(A_2B_2C_2) = 65$. The sample totals for each class in Table 1 now become

$A_1 = 4600$ $B_1 = 3950$ $C_1 = 3250$
$A_2 = 4100$ $B_2 = 4750$ $C_2 = 5450$

Some of the results are presented in Tables 3 and 4. The usual weighted analysis incorrectly indicates the presence of (BC) and (AB) interactions. The least squares analysis is definitely superior to the unweighted analysis in detecting an interaction.

In analyzing disproportionate frequency data, it seems inadvisable to use the usual weighted analysis. This author usually advocates using the unweighted analysis except when some cells are blank or have only one or two entries. In the latter cases, the least squares analysis has been used when there was time and facilities to handle the computing. However, one might consider the use of a missing-plot formula to estimate the means for blank cells by minimizing the interaction sum of squares.

A recent type of experimental design, the *fractional replication design* may become quite useful in designing samples for analytical surveys, where certain cells are expected to be empty. Suppose we have 4 factors, each with two classes, as follows:

		A_1		A_2	
		B_1	B_2	B_1	B_2
C_1	D_1	X	Z	Z	X
	D_2	Z	X	X	Z
C_2	D_1	Z	X	X	Z
	D_2	X	Z	Z	X

TABLE 4. LEAST SQUARES SOLUTION FOR (A_2C_2)

Original Equations

Mean	A_2	B_2	C_2	(A_2C_2)	Total Price
200	100	100	100	65	8,700
	100	15	65	65	4,100
		100	30	5	4,750
			100	65	5,450
				65	3,025

Forward Solution

Mean	A_2	B_2	C_2	(A_2C_2)	Total Price
200	100	100	100	65	8,700
1	.5	.5	.5	.325	43.5
	50	−35	15	32.5	−250
	1	−.7	.3	.65	− 5
		25.5	−9.5	−4.75	225
		1	−19/51	−19/102	450/51
			2140/51	1070/51	64200/51
			1	1/2	30
				91/8	−455/2
				1	− 20 = (A_2C_2)

$$d_a = 30 + \tfrac{1}{2}(20) = 40;\ d_b = \frac{450 + 19(40) - 19(10)}{51} = 20;\ d_a = -5 + 14 - 12 + 13 = 10.$$

It is known that there are few, if any representatives in one or more of the Z-cells. If samples are taken for only the 8 X-cells, the averages for these cells can be used to estimate the differences between the two classes for each factor and also to give some indication of the presence of two-factor interactions. Conversely one could use the 8 Z-cells if one or more of the X-cells were empty. If one X-cell and one Z-cell were empty, it might be possible to set up a balanced design, but the factor differences would be mixed up with 2-factor interactions.

One method of avoiding the difficulties of planning a balanced survey is to obtain the data in a planned experiment. In 1948, Dr. H. L. Lucas and the author designed a balanced regional experiment to study the effects of improved and supplementary pastures and farm feeding on seasonal milk production. The experimental plan is given in Table 5. This is a balanced $4 \times 3 \times 2$ factorial experiment in blocks of 12 animals, with a complete set of treatments at each experiment station. Unfortunately funds were not available to carry out the experiment; however, there is indication that it may be reconsidered. It is presented here as a conclud-

TABLE 5. PLAN OF SEASONAL MILK PRODUCTION EXPERIMENT

1. Each of nine cooperating states participate in the trial with their herds at both their central station and sub-stations, comprising a total of 18 herds, with two herds in each state.
2. The year will be divided into 4 calving seasons.
3. Cows selected from each calving season will be subjected to three pairs of treatments as follows:
   A. 1. Ordinary pastures[3] without supplementary feed during pasture season.
      2. Improved pastures[4] without supplementary feed during pasture season.
   B. 1. Ordinary pastures with moderate[5] supplementary feed during pasture season.
      2. Improved pastures with moderate supplementary feed during pasture season.
   C. 1. Ordinary pastures with optimum[6] feeding the year round.
      2. Improved pastures with optimum feeding the year round.
4. The experimental design will consist of 18 herds of 12 cows each, two herds being in each state. The division of animals within herds by seasons and treatments will be according to Plan 6.14 (Cochran & Cox—*Experimental Designs*).[7]
5. Feed intakes, quality of pasture, production, butterfat percentage and body weights shall be checked carefully for entire year.
6. Results may be compared with D. H. I. A. records for a check of usefulness of D. H. I. A. records in determining relative costs of milk production by seasons of freshening.

ing example of the possible use of experimental design in farm economics research.

Summary

Four surveys are presented as examples of the need for better planning of research projects. A number of specific recommendations are presented for reducing research errors, such as clearly defining the problems, outlining in advance the analysis of the data and using accepted sampling techniques. An artificial example is used to compare various computing methods for comparing averages with classification data. Finally some suggestions are made for using modern experimental designs, such as fractional replications, in farm economics research.

[3] Ordinary pastures are considered as pasture mixtures with relatively low yields and short length of grazing seasons, and exclude supplementary pastures.

[4] Improved pastures are those having higher yields of succulent feed over a longer grazing season and may include supplementary pastures.

[5] Moderate supplementary feed means the rate of grain feed in the summer most commonly practiced by grade A dairymen in the South. This means not more than one pound of grain to four pounds of milk and no additional roughage except in the case of drought or complete pasture failure.

[6] Optimum supplementary feed means the quantity of grain and roughage calculated as necessary for supplying nutrients at a level to maintain production in line with minimum lactation declines.

[7] Cochran, W. G. and G. M. Cox (1950), *Experimental Designs*, John Wiley & Sons, Inc., New York.

AGRICULTURAL PROBLEMS OF THE MIDDLE EAST*

L. D. SCHWENG

Introduction

IN THIS paper, the Middle East denotes the Arab countries of the Arabian Peninsula and in particular countries of the Fertile Crescent, the belt of higher rainfall in its north west and north. Israel is excluded because while physically in this area, it does not fit into its pattern and Israel's problems are different.

It is a fascinating region, full of contrasts, full of puzzles, full of possibilities, but beset with grave problems. The difficulties which hinder the realization of the possibilities are to some extent due to nature; while many are made by man this does not seem to make solution any easier.

First of all there are striking contrasts between regions with highly productive and well watered lands and barren desert with hardly any rainfall and no possibility of irrigation; there are the contrasts between intensive cultivation of flatlands and hill sides and ruinous ways of extracting a return from the soil; there are the contrasts between up-to-date methods of good farming and age old primitive methods of cultivation and implements; and finally there are the contrasts between the memory and relics of a glorious past and the bleak and difficult present.

Agriculture is the principal industry of the region. It provides employment for the largest number of people, even if it has given way to oil royalties as the principal source of wealth which now flows into this area. Just as with oil, the factors that are vitally important for agriculture, are unevenly distributed.

Climatic Factors[1]

The limiting factor of agricultural production is water. Of land, and good land, there is an abundance. But much of it cannot be utilized because there is not enough water to raise crops.

The rainfall of the area is confined to the winter months, from November to April; there are no rains during the remaining six. Even dur-

* The paper is a somewhat extended version of a lecture of a similar title given in the Near East Seminar of the Foreign Service Institute, Department of State. The author recently spent nearly a year in Jordan as a Technical Assistance Expert of FAO studying the possibilities of argicultural development, the plans and policies that had been evolved and eventually drawing up a plan himself. He had occasion to visit Lebanon and Syria and was in personal contact with agricultural officials and expert advisers in these and other countries of the region and had access to much unpublished material on Jordan and the surrounding countries.

[1] For a detailed discussion of the climate and other physical characteristics of the region see N. B. Fisher, The Middle East, A Physical, Social and Regional Geography, London, 1952, 2nd Ed.

ing the winter the total amount of rainfall is small. Generally it decreases going from north to south and from west to east. Nearer to the coast and at higher altitudes it may reach as high a figure as 40 inches but areas with such high rainfall are small in comparison with those in the 20-30 or 10-20 inch range or even below. Much of the rain runs away instead of soaking into the ground. It is a pitiful sight to see freshets wash away good soil, flash floods carry away roads and bridges and damage villages and towns, knowing that within a few months every drop of water will become precious.

There are great fluctuations in the total amount of rain from year to year and serious shifts in the pattern of its seasonal distribution. Over very large parts of the cultivated area the normal rainfall is barely sufficient to raise one crop and the all too frequent deficiencies of 40, 30 or even 20 per cent mean disaster.

For the reasons mentioned, the flow of springs and rivers shows considerable variation from year to year and within the year. Topographical features of the region make the storage and better utilization of the water of perennial streams difficult in many cases.[2]

To what extent the climate and the water regime of the region have changed is undecided. Some authorities believe that there has been no fundamental change; but in marginal areas cyclical changes in the yearly amount of rainfall could have had very marked effect, although the action of man, in over-cutting and overgrazing, could gradually wipe out the benefits of periods of higher rainfall. There are others who think that the climate and water regime of the region, or over parts of it, had been more favorable to agriculture and that less of the area was marginal. It is a fact, established by excavations, that areas which are now pure desert or semi-desert, once carried prosperous human communities which could hardly have existed had the conditions been the same as today.[3]

Historical Factors

It seems certain that over most of the region man lived constantly in a precarious balance in a hard fight against an inclement and cruel nature. This may have been one factor which led to organized community life

[2] For a detailed discussion of the difficulties encountered in planning irrigation in the Jordan Valley and the other valleys of Jordan see M. G. Ionides, Report on the Water Resources of Transjordan and their Development, including a Report on the Geology, Soils and Minerals and Hydrological Correlations by G. S. Blake, London, 1939 and Sir Murdoch Macdonald, Report on the Proposed Extension of Irrigation in the Jordan Valley, London, 1951. For a background of these reports and the broader problems involved, see M. G. Ionides, The Disputed Waters of Jordan, The Middle East Journal, Vol. 7, No. 2, Spring 1953, 153 ff.

[3] For a recent summary of archeological evidence, see Gordon V. Childe, New Light on the Ancient East, London, 1952, 14 ff. and 102 ff.

in the valleys of the great rivers and made the region one of the cradles of civilization.

However, irrigation farming on which this civilization was based, requires continuous and high traditions and discipline and the maintenance of elaborate installations. Once these are destroyed and repair is delayed, reconstruction becomes progressively more difficult because, through natural factors, the extent of the damage continues to grow. At the same time the traditional skills and discipline required for irrigation farming become weaker until they completely vanish. *Mutatis mutandis* the same holds true of the terraced agriculture of the hilly districts.

The region had more than its due share of invasions and wars and the results were catastrophic. Destruction and devastation in regions like Eastern Europe with more favorable climatic conditions and with less marginal agriculture could be made good within a generation or so, but in the Middle East left wounds which were slow to heal if at all.

Centuries of Turkish rule brought relative peace but no prosperity. The Turks were negligent of the economy of the regions they occupied, and exacted tribute but did little to develop the resources of their domains to raise the levels of living of the people under their rule. In this the Middle East fared no better than Eastern Europe. By a curious turn of fortune, the great transformation of the Turkish State and of the Turkish attitude to economic development came after Turkey had lost its provinces on the Arabian Peninsula.[4]

The Peninsula, having all the characteristics regarded as the principal attributes of the nation state, was split into arbitrary units by the western powers after World War I. Thirty years of independent statehood made for separatism and the tendency is reinforced by the inequality of wealth from oil and by personal rivalries. Economic considerations, particularly the pooling and efficient use for capital development of the great flow of income from oil and the full utilization of the water resources of the area, all speak for integration. Even today integration has fewer obstacles and greater advantages on the Arabian Peninsula than in some regions elsewhere in the world where it is being pushed with greater vigor.

The Problem Areas of the Middle East

Marginal areas like those in which the Arabian Peninsula abounds exist elsewhere in the world, notably in the United States. But there are great differences in their setting, not to be overlooked in comparing their present status and future possibilities of development. In the United

[4] Cf. Philip K. Hitti, History of Syria, London, 1950, 667 ff. and G. E. Kirk, A Short History of the Middle East from the Rise of Islam to Modern Times, London, 1949, 58 ff.

States the marginal areas are small in comparison with the good agricultural areas; they hardly count in the long list of assets of a country rich in most kinds of natural resources; their development is an important but relatively small task for a tremendous economic and administrative organization maintained by and serving the needs of a rich economy; and this organization had been built up in developing regions where the marginal productivity of capital and skills were not only great but also where returns were quick to mature. Last but not least, people do not have to live in marginal areas; there are opportunities for them elsewhere and they are free to move.

In the Middle East the marginal areas are vast in comparison with the more promising ones and most of those are already settled—sometimes densely settled. The population could, within limits, be distributed in a more rational manner within the region but, even overlooking political obstacles, this would still leave many people in marginal areas. Worse still, these areas do not have the generating centers equipped for the task of developing them. Nowhere are the skills required for large scale development available. The skeleton administrations hardly can cope with the day-to-day problems of government. Oil, the principal source of capital for development, is distributed unevenly. Iraq has more water and land in relation to its population than any other Arab country, and is also rich in oil, while countries like Jordan which need much capital and where the marginal productivity of capital is low, do not have oil. Under the given circumstances, development would be a very much slower process than it has been in the United States and cannot be expected to yield anything like comparable returns.

Land Tenure

Of the man-made factors that influence agriculture, land tenure is certainly one of the most important. The defects of land tenure in the Middle East have frequently been described and discussed. Some authors believe that it is the principal cause of poverty and backwardness in the region.[5] However, the picture is by no means as uniformly bad as it is commonly supposed to be, nor are reforms leading to real improvement as easy. In Lebanon, in Jordan, and in some parts of Syria and Iraq, the land is farmed in small holdings by owner-occupiers; yet many of them are poor, sometimes desperately poor. Except in rather well-defined favorably situated areas, individual ownership of land in small holdings does not seem to be a sufficient condition for generating a prosperous and progressive agriculture.

[5] Cf. Doreen Warriner, Land and Poverty in the Middle East, London, 1946, especially 4 ff. and Afif I. Tannous, Land Reform: Key to the Development and Stability of the Arab World, The Middle East Journal, Vol. 5, No. 1, Winter 1951. Reprint.

Detailed and accurate statistical information on the distribution of land by ownership and size of holdings is not available for most countries. In obtaining data and in evaluating them, there is difficulty in applying our concepts of tenure in countries where the tribal organization of society still prevails, if not in the whole country then in parts of it, where individual property rights attached to land are not universally recognized or even cherished and where the social and economic climate is very different from our own.

Too few resources for the development of balanced economies, their scatter in desert or semi-desert country, lack of markets, lack of transportation, a general lassitude of the economic climate in which natural factors play a role all make their mark on landlords, sharecroppers, and small holders. In their attitudes and actions people are influenced not only by their actual state but also by their expectations. One need not go east of Suez to see how people's attitude can change in matters of enterprise and security when opportunities become limited and the prize of venture becomes too small or too risky.

In the Middle East the ownership of land, the hoarding of gold and of jewels are the safest ways for storing wealth just as trade is the best and most rewarding way for building it up. This explains at least to some extent the landlord's attitude towards land. The lack of opportunities, lack of example and guidance, lack of institutional buffers against calamity (which are characteristic of highly developed countries) and the all too frequent calamities go a long way to explain the helplessness of the peasants. The prosperous agricultural communities are found in regions where there is enough land per head of the population and where nearness to markets, ease of transportation, example and guidance, and better educational opportunities were able to break down the great inertia of rural life built up in oppresive heat and great isolation, in uninviting and inhospitable country.

Efforts to change the pattern of tenure have not been lacking. In at least one country, Jordan, the village ownership of land with the periodic reallocation of fields to families has been abandoned and individual ownership has been established. At the same time, state-owned land has been turned largely into small holdings. But redistribution could not remedy the basic shortage of land and most of the holdings are much too small to keep a family fully occupied and ensure a tolerable level of living, especially where the prevailing type of subsistence farming could not be changed. The subdivision of land led to fragmentation and conservation measures have become very difficult.

In other countries surveying and registration of land has not progressed so far; in still others the allocation of titles turned much of the state-owned land to notables. But with the disintegration of tribal organization

and increased pressure of population on land, the system of tenure and the pattern of distribution of land are changing even if the rate of change is uneven in the region as a whole and is in many cases very slow.

There have also been examples of settlement on newly opened up land. There is the Dujaila land settlement scheme in Iraq and there are smaller schemes elsewhere. In Jordan such schemes aimed at the settlement of Arab refugees from Palestine. Most schemes have not been unequivocal successes for a number of reasons. Sometimes technical points, such as the provision of adequate quantities of good water or providing drainage have been overlooked. In others, the method of selection or the rather lavish distribution of land gave rise to a new small landlord class. Sometimes no provisions were made for technical advice to the new farmers who as owners continued the wasteful and inefficient practices they had been using as sharecroppers. The new communities suffered from either too close organization abhorrent to Arabs who, for all their other virtues, are not noted for their sense of cooperation and discipline, or they veered to the other extreme and failed to provide an organized framework for community life. Sometimes the schemes have been too ambitious in their layout.

If real advance is to be made, the limitations of land reforms and the lessons of the schemes in the Middle East would have to be studied in addition to the causes and consequences of the unequal distribution of land.[6]

The Problems of Increasing Agricultural Production

Agriculture in the Middle East is self-sufficient for the region as a whole and is subsistence farming on most of the farms. Except in dates, the region is not an important exporter of agricultural products. What exports there are, are small in comparison with total output and are subject to erratic fluctuations.

Cereals, wheat and barley depending on climate and soil, and to a far lesser extent millet, sorghum and corn are the most important field crops. Leguminous crops, lentiles, broad beans, chick peas and cash crops like sesame, tobacco, recently cotton are grown but their acreage is too small to allow for good rotation. Fallowing the land every second or third year is a customary practice which means that only about half of the total cultivated acreage is actually under crops. Per acre yields vary greatly from year to year and tend to be low. In the case of wheat and barley they are at about the level of the United States. But yields which may be justifiable in a country where the man-land ratio is high, are a

[6] Cf. Raleigh Barlowe, Land Reform and Economic Development, *This Journal*, XXXV: 2 May 1953, p. 176.

matter of grave concern in countries where the ratio is unfavourable and is steadily getting worse.[7]

Fruits are an important product of the region. Dates, olives and a number of other fruits and grapevines are grown extensively where the climate and soil are suitable. The standard of fruit growing is no better than that of growing field crops except where fruit becomes the dominant or most important crop.

Livestock contributes a modest share to the total agricultural output but is not an integrated part of agriculture. The animals depend for sustenance largely on marginal grazing lands, and on the stubble and fallow; little feed is grown for them and they are not given much attention and care.

Although the seriousness of the situation varies from country to country, at its present level agricultural production provides but a meager diet for the population, and in view of the rapid population growth its rate of increase is very unsatisfactory. In some of the countries, notably Iraq and Syria, production can be increased by bringing new land under cultivation with irrigation. But irrigation must not be looked upon as the only solution. There are countries like Saudi Arabia, Jordan and Lebanon where the acreage of irrigable land is limited. Besides, if irrigation is to fulfill the hopes set on it, more will be required than the building of irrigation works and bringing water to the land. In the region where irrigation farming was first developed, present methods of irrigation are very inefficient.

In areas which depend entirely on rainfall, limited expansion is possible and increased production requires an improvement in per acre yields. The extraordinary variation in per acre yields in similar areas is suggestive of the considerable latent reserves of the region. Not very far from holdings of owners who have no desire or no ability to develop their lands, where land is lying in waste or is turned over to uninstructed and miserable sharecroppers or from the holdings of small farmers who cultivate their land in a primitive and wasteful way, one can find farms, private and government, large and small, employing efficient methods of farming and management. The small farmers left to themselves and working far from markets in an environment which limits their choice of crops, will tend to grow what their families physically need and will stick to their traditional ways. Given example and leadership and an opportunity to sell their products, they are ready to venture into new fields and learn new

[7] For a more detailed discussion of the various problems involved see Middle East Supply Center, Proceedings, Conference on Middle East Agricultural Development, Cairo, 1944, B. A. Keen, The Agricultural Development of the Middle East, London, 1945, and E. B. Worthington, Middle East Science, London, 1946.

techniques. A comparison of areas similar in character in West Jordan, Arab Palestine, which had been part of Palestine under the Mandate and East Jordan, the former Transjordan, not to mention other regions farther away, is very instructive and gives food for thought.

It is unfortunate that in most countries of the Middle East good farming has become associated in people's minds with the use of power-driven machinery. There are areas with large tracts of level land, free of stones, with farms and fields large enough and a sparse population where the use of such machinery is indicated. But over most of the region the gradients are too steep, the ground is too stony and the farms and fields too small for the efficient and economical use of tractors. The technical and economic limitations on the use of machinery tend to be overlooked by richer people who buy them to prove that they are progressive or by agricultural officials who advocate their use. The dislocation that indiscriminate use of machines can cause in countries where labor is the one abundant factor can be very serious, particularly since demand cannot be created rapidly in other employments. The purchase and operation of machines is a risky venture with at best a deficient banking structure and hard-to-meet cash costs. The problems of repair and maintenance present nearly insurmountable problems. Worst of all, the fascination of the machines have turned people's minds away from other ways of improving yields which would be less costly and which would, in fact, be the prerequisite for getting the full value out of the machines where their use is justified.

Key problems of Middle East agricultural improvement are sounder land use and water conservation. Man cannot make up for inadequate rainfall but can greatly reduce wasteful run-off, can steady the supply of water from springs and streams and can reduce the drying effect of the winds. This requires the restoration of the tree cover in hilly districts where there is enough precipitation to sustain trees; the terracing of cultivated fields where the gradients are steep and contour farming and strip cropping on more level lands; water spreading in the semi-desert areas and the storing and efficient utilization of every drop of water in streams.

Few countries in the Middle East are aware of the basic importance of these measures. Jordan is outstanding in that it has embarked on a well-conceived and well-executed policy of afforestation although, owing to lack of funds, the rate of progress is not as great as it could be. But even in Jordan present methods of crop production are often destructive.

Once crops are grown where they should be and greater care is taken in their cultivation, the long process of impoverishment caused by abuse and various forms of erosion is halted. Plant life will literally have a deeper and firmer basis than now and yields will improve. Better varieties

of the crops now grown and an extension of the range of crops by new additions, carefully chosen on the basis of climatological analogues, could provide further increases of production.

This, of course, is a long range program and its fruits would mature slowly. Its implementation would have to go side by side with correcting the obvious defects of cultivation, the distribution of better seed, the introduction of better implements, together with the fighting of pests and diseases which so far has been the principle field of action of the agricultural administrations.

Local Attitudes to and Plans of Development

In the Arab countries there is no lack of efforts and plans to develop agriculture.[8] But so far the rate of progress has been slow, much slower than the pressing needs of the present populations or the rate of their growth warrant. The fault lies partly in plans and policies and in the administrators and planners responsible for them, and partly in the great difficulties under which they labor.

In most countries of the world, and most certainly in the countries of the Middle East, farming is not a trade people would learn, a business proposition they would take up or continue as a result of considered judgment. The people who farm are born on farms, acquire farming skills as part of their pattern of life and go on farming because there is nothing else for them to do. The fact that most of the farming is subsistence farming is an additional factor working against change. The way in which prices affect costs and act as incentives or checks on small but market-oriented farms in highly developed countries is an unsafe guide in dealing with the small subsistence farms of the Middle East.

The seclusion of women and their inferior educational opportunities resulting from their status rules them out as a factor working for change and improvement, although they carry an undue share of the work on the farms.

Youth has few opportunities to learn farming skills outside the family farm or the village and has no opportunity to apply on the home farm the skills it might have picked up before it takes over. Farm size is in general much too small and the balance on which they operate is much too precarious to let youth experiment.[9]

Distrust of the government and government officials is also a potent

[8] For a detailed discussion of such plans see United Nations, Final Report of the United Nations Economic Survey Mission for the Middle East, New York, 1949 Parts I and II, and Headley V. Cooke, Challenge and Response in the Middle East, 1919-1951, New York, 1952.

[9] For a more detailed discussion of the role of education in agricultural improvement see H. B. Allen, Rural Education and Welfare in the Middle East, London, 1946.

force. The Arab states of the Arabian Peninsula are the creations of the 1920's. Thirty years have not been enough for the building up of effective government machinery and even less so for making people accept the governments as their own, when they had been used to government from outside and had learned to view its activities with suspicion. Under such conditions the best government would have great difficulties in asserting its authority and in winning the confidence of the people. Unfortunately good government cannot be created overnight either; inevitable mistakes bring set-backs and make progress even slower.

Strange as it may sound, the people whose task it would be to bring about a change, the progressive trained officials in the various branches of the agricultural administration often increase antagonism to change instead of breaking it down. Through the very fact of their superior training they become far removed from the peasant's way of thinking and his way of life which becomes manifest in their dress, speech, manners. They develop into specialists and the problems of the small farms become too small for them. A number of them received their technical training in western countries and are eager to imitate what they have seen but often lack application. With their unqualified admiration for things different and modern and sweeping contempt for tradition and practices deemed antiquated they want to throw everything overboard.

What is characteristic of the progressive and western-trained administrators and technicians is perhaps even more characteristic of the high level planners and the plans they draw up. Planning has become like magic. In taking it over as a policy, the great differences that exist between countries tend to be overlooked. Large scale government action has its prerequisites in government machinery and in the climate in which it operates. Building up the machinery and creating a climate for its successful operation requires time and concentrated effort and does not contribute directly to the solution of problems. But the planners seeing the problems of their countries in their national dimensions and feeling the urgent need for action become impatient of piecemeal work and day to day drudgery. In their zeal they acquire a strange air of unreality, a disregard for the human factor in implementing the plans. They are apt to forget that reaching "targets" requires, ultimately, that untold numbers of small farmers do things in a different way and conform to their ideas. But they think of agriculture in abstract terms and have little understanding of the realities small farmers have to face.

There develops thus a deep conflict. The peasants see that people living in faraway towns condemn methods they had seen and used all their lives and are anxious to reorganize their lives. If things go well, they are smothered with instructions, suggestions and advice, but the responsibility

for putting strange ideas into practice and the risk of doing so remain theirs. It strikes them as strange that people who are so anxious to improve their lives and are so convinced of the success of their ideas should always advise them from safe jobs in towns instead of settling down in the village, where they could demonstrate their superior ability and the success of their superior techniques while facing the same limitations and difficulties they have to face. This naturally makes them distrustful and antagonistic.[10]

Whatever the merits and demerits of the plans and policies of the agricultural administrations and administrators, in many cases they have been badly handicapped by lack of funds. Even where funds could be made available it is not sufficiently realized that without advance in agriculture there can be no sound development in economies which are still largely agricultural, and that without a certain amount of expenditure, no real advance is possible. A token agricultural budget cannot be expected to produce results, even if the money is well spent. If, as is often the case, a fair proportion of the funds goes into expensive buildings and installations, beautiful to look at but far removed from the realities of life around them, progress becomes even slower than it need be. The harm does not end in having wasted funds that could have been spent on modest but vital projects. If the schools and other establishments are in glaring contrast to the ordinary village and the peasant farm, the trainees, future farmers and officials, will be conditioned away from the village, will be induced to stay in towns and will thus become unable to raise the level of rural life and of agriculture.

The Western Attitude—Conclusion

The interest of the western countries in the agricultural development of the Middle East is older than the technical assistance programs. Not to mention earlier and scattered efforts, a great concentrated effort was made during World War II to increase production in order to save shipping and make the region not only self-sufficient in basic foods but also capable of supplying the Allied Armies with food, some industrial goods and services. The work of the Middle East Supply Center was a promising beginning.[11] In the deteriorating political atmosphere of the post-war period the good start could not be followed up. After a break of a few

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[10] For interesting examples of how to overcome this distrust and of successful rural development schemes see H. B. Allen, Rural Reconstruction in Action, Experience in the Near and Middle East, Ithaca, N.Y. 1953.

[11] For a history and an appraisal of the work of the British Middle East Supply Center see Martin W. Wilmongton, The Middle East Supply Center: An Appraisal, The Middle East Journal, Vol. 6, No. 2. Spring 1952, 144 ff.

years, while the field had been held by the British Middle East Office, international technical assistance and Point Four appeared on the scene. The new programs have not operated in the area long enough to produce statistically measurable results.[12] Agricultural statistics in the Middle East are noted for their limited reliability and technical assistance is, in a sense, providing a measuring rod of its own achievements when it improves the agricultural statistics of the region.

With varying emphasis, here as elsewhere, three main lines are discernible in the western approach to the problems of underdeveloped areas.[13] Some believe that the main impetus to development is given by a sufficient influx of capital. There are others who think that what is most needed is technical knowledge, both at the level of the peasant farmers and at the level of those responsible for guiding their activities. A third school of thought believes that without political and social reforms improvements brought about by an influx of capital or "know-how" will enrich but a few and will not improve the generally very low levels of living of the masses.

A detailed discussion of these three schools of thought and their impact on underdeveloped countries will have to be left to another paper. The Middle East will provide some puzzling illustrations of the application of these ideas.

To sum up, there is scope for considerable increase in the agricultural output of the Middle East if only the wasting of its natural resources could be stopped and land and water could be put to sound and efficient use. The problems are formidable. What is most needed is a realistic approach to the problems, courage and modesty in beginnings and perseverance in carrying out schemes once decided upon. Perhaps to an even greater degree than elsewhere, in the Middle East the best has been the enemy of the good.

Farming all over the Middle East is a struggle against nature at its cruelest and success is not easy for the peasants. Nor is it easy for those who want to help them. They must share their doggedness and must

[12] For an exposition of the problems rather than a discussion of the achievement of the programs see Halford L. Hoskins, Point Four with Reference to the Middle East, The Annals of the American Academy of Political and Social Science, Vol. 286, March 1950, 85 ff. and J. C. Hurewitz, Middle East Dilemmas, New York, 1953, 207 ff.

[13] The problems of economic development of one of the countries discussed in this paper, Iraq, are analysed in detail in The Economic Development of Iraq, Report of a Mission Organized by the International Bank for Reconstruction and Development, Baltimore, 1952. More modest in their scope and less exhaustive in their treatment of the problems are the Reports of the United States Agricultural Missions to Syria and Lebanon respectively, Office of Foreign Agricultural Relations, United States Department of Agriculture, International Agricultural Collaboration Series, Nos. 4 and 7.

have a sense of dedication for they must stoop to raise them. The level of rural life and of agriculture cannot be raised from faraway urban centers. Educated local men must face spending their lives in villages to teach their simple fellow citizens by example. And expert advisers who are needed from abroad would have to be prepared to, and be let to, stay in the countries for years instead of months; to be successful they would have to excel not only in technical knowledge but even more in realism, patience and perseverance. The lack of these qualities is the greatest obstacle to Middle East progress.

NOTES

SOME RECOMMENDATIONS FOR STANDARDIZING FARM MANAGEMENT TERMINOLOGY

A PRECISE and standardized vocabulary facilitates accurate communication of thoughts and ideas in any professional field. Technical terms that mean one thing and one thing only whenever and by whomsoever used avoid confusion and misunderstanding. They also save considerable time, space, and words by making it unnecessary to define such terms in oral and written exposition.

The use of standard terminology does not imply the standardization of methodology. Research workers should be strongly encouraged to develop more effective research methods. As new methods are developed, new terminology should be devised to serve as a medium of expression for the new methods. The use of old terms that have an established connotation in a new or modified sense leads only to confusion. In a dynamic science such as farm management, systematic attention to the precise use of standardized terms is especially important and the development of new terminology to fit changes in methodology is imperative if confusion of thought and expression is to be avoided.

The need for a precise definition and standardization of terms used in farm management research has long been recognized. In 1914, the Executive Committee of the American Farm Management Association appointed a committee on terminology which presented its first report at the annual meeting of the Association in November, 1916.[1] At the annual meeting in December, 1917, this committee recommended a list of 20 definitions of common farm management terms.[2] In 1919, after the American Farm Management Association had become the American Farm Economic Association the same terminology committee presented a report that largely repeated the definitions of the previous year.[3] This committee was continued as a standing committee for a number of years.

In 1936, renewed interest in standardizing farm management terminology developed in the American Farm Economic Association. In response of action taken at the annual meeting that year, the President appointed a new committee to define terms used in farm management.[4] This committee remained active and worked on its assignment for five years. At the annual meeting of the Association in 1940 this committee submitted a report which included recommended definitions for 51 terms in common use in farm management literature.[5] This report was accepted at the annual meeting in 1941 and the committee discharged.[6]

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[1] Proceedings, American Farm Management Association, 1916 p. 85, 1917 p. 122.
[2] *Ibid.*, 1918 pp. 192-193.
[3] *This Journal*, Vol. I, No. 2, pp. 76-77.
[4] *Ibid.*, Vol. XX, No. 1, p. 399.
[5] *Ibid.*, Vol. XXIII, No. 1, pp. 369-76.
[6] *Ibid.*, Vol. XXIV, No. 1, p. 350.

The final report of the committee just mentioned contains this very significant statement, "the committee recognizes that the development of terminology is a dynamic and evolutionary process." The need for further work along this line is still with us. Some of the terms defined by this committee in 1940 are being used at the present time with a connotation differing distinctly from that specified by the committee. The term "labor income" for example, for which a specific definition was recommended by the committee of the American Farm Economic Association in 1917 has been computed and used too frequently in a manner differing from the standard definition. Similar examples of careless or inexact use of terms could be cited. Then, too, there have come into the picture new measures and new types of analysis that call for new and precise definitions.

Because of this continued need for standardization of farm management terms, particularly those used in the analysis of farm accounting records, the North Central Farm Management Research Committee at its meeting October 22-24, 1951, requested its subcommittee on farm records to give the subject further attention.[1] With the cooperation of farm management research workers of the member agencies represented in the Regional Committee, a study was made of farm management concepts in common use for which standard and generally accepted terminology and definitions were needed. The report of the sub-committee covers 21 terms, the first 14 of which are used primarily in computing measures of farm financial success.

The appended report contains fewer terms than the American Farm Economic Association report of 1940, although some measures not used in the earlier report are included. The chief departure from the 1940 report is the recognition of a distinction between the terms "labor income" and "labor earnings" and the subsidiary definitions associated with them. "Labor income" was the first measure of farm financial success to come into general use. Later, as more data became available, the "labor earnings" or "labor and management earnings" measure was developed. The inclusion in or exclusion from gross income of the living from the farm furnished to the operator, his family, and hired laborers (often called "farm perquisites") constitute the sole difference between these two measures. In the case of "labor earnings" the value of the living from the farm is included in the gross income, whereas in the case of "labor income" it has been excluded. These two terms for any particular farm differ only

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[1] The agencies represented in the North Central Farm Management Research Committee are the Agricultural Experiment Stations in Illinois, Indiana, Iowa, Kansas, Kentucky, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin; the Bureau of Agricultural Economics, U.S. Department of Agriculture, and the Farm Foundation of Chicago.

by the value placed upon "farm perquisites." This is a distinction that has been observed over a considerable period of years.

The standard definitions recommended by the American Farm Economic Association in 1940 did not include "labor income." But the authors of the report presented herewith feel that since a substantial proportion of farm management research workers still use the term "labor income," it should be included in any list of standard definitions. The sub-committee has also prepared definitions of other terms used either in computing "labor income" or "labor earnings" or as additional measures of farm financial success. In those carrying the term "income" such as "net farm income," "capital and management income," and "rate of income on capital" the value of "farm perquisites" has not been included in gross income. In those carrying the term "earnings" such as "net farm earnings," "capital and management earnings," and "rate of earnings on capital" the value of "farm perquisites" has been included in gross income. By following consistently this distinction between "labor income" and "labor earnings" and between definitions subsidiary or related to them confusion can be avoided.

The sub-committee of the North Central Regional Farm Management Research Committee in presenting its report does not assume either that it has covered all farm management terms which need clarification nor that its contribution will clear up all confusion in the use of farm management terminology. There may be additional terms that should be defined, old measures may need to be revised or modified from time to time and new measures devised to implement new developments in farm management research. The sub-committee hopes that other regional farm management research committees will review this report, criticise it, and carry on from where it left off. Perhaps the American Farm Economic Association should set up a new committee to act either independently or in cooperation with the regional farm management research committees to continue this dynamic process of maintaining a reasonable degree of uniformity and consistency in the use of farm management terminology.

Definition of Terms Used in Farm Record Analysis Recommended by North Central Farm Management Research Committee

1. *Total farm capital* is the value of land with such permanent improvements as are ordinarily transferred with the title to the land, livestock, equipment, and other supplies constituting together a farm operating unit.
2. *Cash receipts* include the cash value of all sales of farm products, services, and equipment, and other receipts from normal farm operation.
3. *Value of farm production* is the sum of the cash receipts, any increase in feed and livestock inventories, and the value of farm products furnished to the farm family; minus the sum of the sales of farm machinery and improvements, and decrease in feed and livestock inventories, and feed and livestock bought.

4. *Cash expense* includes the cash cost of all goods and services purchased for use in the farm business exclusive of interest.
5. *Net cash income* is cash receipts minus cash expenses.
6. *Net farm income* is the net cash income plus an increase (or minus a decrease) in total farm capital other than bare land, and minus the value of unpaid family labor (not including operator's labor).
7. *Net farm earnings* is the net cash income plus an increase (or minus a decrease) in total farm capital other than bare land, plus the value of farm products furnished to the farm family, and minus the value of unpaid family labor (not including operator's labor).
8. *Capital and management income* is net farm income minus an estimated value of the operator's labor.
9. *Capital and management earnings* is net farm earnings minus an estimated value of the operator's labor.
10. *Labor income* is net farm income minus a charge for the use of total farm capital.
11. *Labor earnings* is net farm earnings minus a charge for the use of total farm capital.
12. *The rate of income on capital* is the net farm income minus a charge for operator's labor. This difference is expressed as a percentage of the total farm capital.
13. *The rate of earnings on capital* is the net farm earnings minus a charge for the operator's labor. This difference is expressed as a percentage of the total farm capital.
14. *Management returns* is labor earnings minus a charge for the operator's labor.
15. *Total acres* includes all land operated as one unit.
16. *Crop acres* are that part of the farm used for crops or summer fallow on which labor and machinery were used during the year, but excluding pasture and woodlots.
17. *Tillable acres* are that part of the plowable land that can be used for crops without additional drainage, clearing, or irrigation.
18. *Rotated acres* are that part of the tillable acres which are cropped in a rotation or crop production sequence.
19. *Work unit* (P.M.W.U.) is the amount of work usually done by a man in a ten-hour day on crops, productive livestock and work off the farm for pay.
20. *Acreage of a specific crop* is the acreage planted to that crop less the portion of the acreage that is subsequently planted to a substitute crop.
21. *Crop yield index* is a percentage ratio of the yield per acre of one or more crops on a given farm to the yield per acre of the same crop or crops on a group of farms. If more than one crop is included in the index, the yield of each crop is weighted by the acres in that crop.

Farm Records Sub-Committee
G. A. POND, *Chairman*
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L. R. KYLE
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A. G. MUELLER

THE EVITABILITY OF TECHNOLOGICAL ADVANCE

(A Rejoinder to the Cochrane-Lampe Article, "The Nature of the Race Between Food Supplies and Demand in the U. S., 1951-75").

IN THE stimulating article, "The Nature of the Race Between Food Supplies and Demand in the U. S., 1951-75," by Cochrane and Lampe, published in the May 1953 issue of *This Journal*, the authors appear to take for granted that technology can always be counted on to deliver the goods in desired quantities if the economic climate is right. This curious faith in the inevitability of the physical capacity of technology is also apparent in Cochrane's equally stimulating paper, "Analysis of Farm Price Behavior," which appeared as Progress Report No. 50 of the Pennsylvania Agricultural Experiment Station in May 1951.

In this earlier paper Cochrane notes in passing, ". . . the great variety of recent and prospective technological developments," and in his summary has this to say,

> "Supply responses typically occur through technological advances, where a new combination of resources makes possible a greater output from a fixed amount of resources. Thus the aggregate supply function shifts to the right when expectations are bright and investments in new methods are widespread."

In the later article the authors state positively that,

> "Farm technological advance will give rise to *continual* and *substantial* increases in the total output of food over the next 25 years even if total inputs hold constant or decline modestly." (Italics ours)

They sum up their position in the following words,

> "In brief, we accept the view presented by Professor John D. Black in early 1949,
>
> 'The major part of the increased agricultural output of the years since 1939 appears to have been due to higher technical intensity of cultivation and new applications of technology. There was a very large backlog of technologies only sparingly used in 1940. My friends in the Agricultural Research Administration of the USDA tell me that there is a surprisingly larger backlog today than in 1940.'"

The backlog Professor Black speaks of here, however, is not a fixed quantity upon which we can draw forever. At that time most students of agriculture were still greatly impressed with the remarkable performance of farmers during the war. While this remains at high levels subsequent analyses taking a longer run viewpoint have tempered judgments somewhat. For example, in June of 1952 the President's Materials Policy Commission published its study, "Resources for Freedom." Professor Black and Arthur Maass of Harvard University prepared Report No. 7 of Volume V of this study under the title "Future Demands on Land

Productivity." Speaking of agricultural land in this report, the authors say:

"Increasing population and better standards of living in the next quarter century and greater industrial requirements for agricultural raw materials will impose a heavier burden on this land base and on agriculture."

Again in Volume I of this report, which summarizes the various studies made for the Commission, we find this statement:

"Technical research in agriculture, which has been the basis of past progress, will be of continuing importance. The work of finding better ways to produce, utilize, and market products should go forward on at least the present scale."

At the direction of the Secretary, a departmental committee was set up to review the report of the Materials Policy Commission and to make its findings available to the President. With reference to Report No. 7, this Committee said:

"It cannot be assumed that production increases will come about automatically. The assumption of continuous increase of production is only valid if research is stepped up and positive efforts made to get research results adopted, if there is a favorable price climate, adequate credit available, and manpower and production facilities—machinery, fertilizer, chemicals, and other supplies—are available in sufficient supply."

In a talk before the National Food and Nutrition Institute in Washington, D.C., on December 8, 1952, Professor Black described the very considerable capacities of American agriculture but commented as follows:

"Although the agricultural land resources of this country have all this potential, we are by no means assured of having all the food that we shall want our people to have. If we were to slacken our research, we would be in real danger. One reason for this is that merely maintaining yields is a constant battle against plant and animal disease and pests. The rate at which new forms and types of these evolve, or present species develop resistance, has been startlingly revealed in the past 10 years."

This shift from one of assurance in 1949 to that of reasonable doubt in 1952 is further substantiated by preliminary findings from studies under way in the Agricultural Research Administration upon which Dr. B. T. Shaw reported in his paper, "The Role of Research in Meeting Future Agricultural Requirements," given before the annual meeting of the American Society of Agronomy, in November of 1952. Here the suggestion is made that much more research will be needed to reestablish the backlog of unused technological knowledge that has been drawn upon in the past.

The approach used in this paper was entirely physical but it had obvious economic implications. It consisted in contrasting year by year for a major commodity, the average per unit production of the farmers of a county or state with the levels of production being obtained in the same

general area under conditions where available research results were rather fully utilized. Such conditions are achieved experimentally in variety testing work with crops or in testing improved strains of livestock. Some times the conditions are approximated by crop and livestock breeders whose main concern is to establish records of consistently high performance regardless of the cost involved. Again they may be found in growers' competition for highest output such as in the Connecticut Egg Laying Contest or the South Carolina 5-acre Cotton Contest for highest per acre yield.

Figure 1 on corn production per acre is illustrative of the approach used. Each succeeding large dot on the broken line of the upper curve, for example, represents a maximum not previously achieved. The smooth curve was fitted by sight to these large dots representing maxima. It thus approximates progress in corn production per acre through time *if all production factors were favorable.*

The outlines of the story of the introduction and adoption of hybrid corn in Iowa are seen rather clearly in Figure 1 and the economist will appreciate the evidence it provides of the considerable lag between availability of research results and their widespread adoption by the average farmer. The vertical distance between the curve representing potential production and that of the average farmer gives some idea of the backlog of research results that may yet be drawn upon. No one, of course, expects this gap to close entirely but its tendency to widen or narrow through time indicates clearly that it is not a fixed quantity. The relative size of the gap at any given time may also provide an index of the research reserve yet untapped by the average producer at that time.

The extent of this research margin over practice may be computed by taking the difference between each year's average and experimental yields and expressing it as a percentage of the average yield for that year. When this was done for this corn chart, an upward trend was in evidence during the period 1918-36, with a generally declining tendency apparent since. Similar comparisons on poultry production per layer in Connecticut as shown in Figure 2 indicate an even more pronounced narrowing of the research margin in the past 2 decades.

A research backlog still virtually untapped is revealed, however, in contrasting pork production per 100 pounds of feed for the top litter of hybrid hogs at Beltsville with the United States average. The proportion of hybrid hogs in the total hog population of the United States is still exceedingly small since they have been available for distribution only during the last 5 years. Preliminary findings then indicate that the size of the research margin currently available will vary considerably depending both on the commodity and the locality under study. On balance, however, the situations where new research results have not been tapped

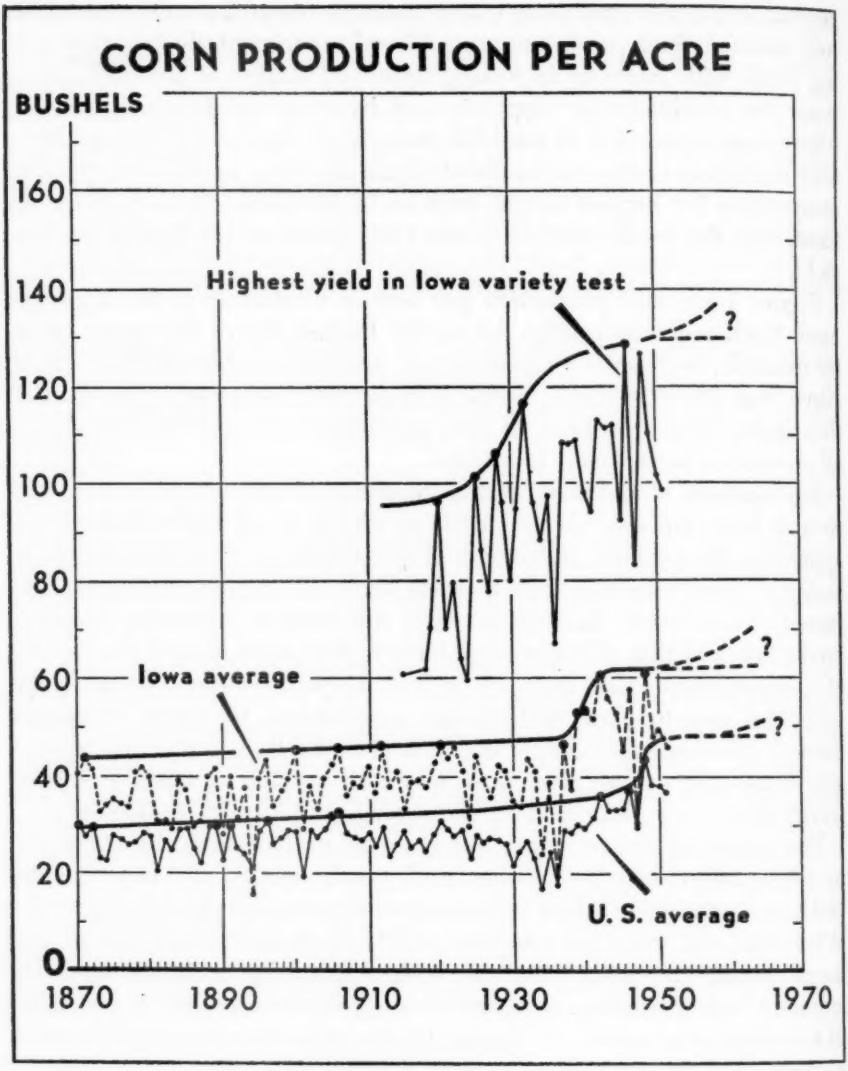

FIGURE 1

to the extent that they are not reflected in higher average production, are few compared with those that have been put into practice.

As an interesting incidental point, Figure 1 offers evidence that one can determine the time lag between availability of significant research findings and their widespread reflection in average practice. The experimental data in this chart started its determined upward march in 1920 but nothing comparable shows in the average corn yields of Iowa farmers till 1937–some 17 years later, and the response of United States average production

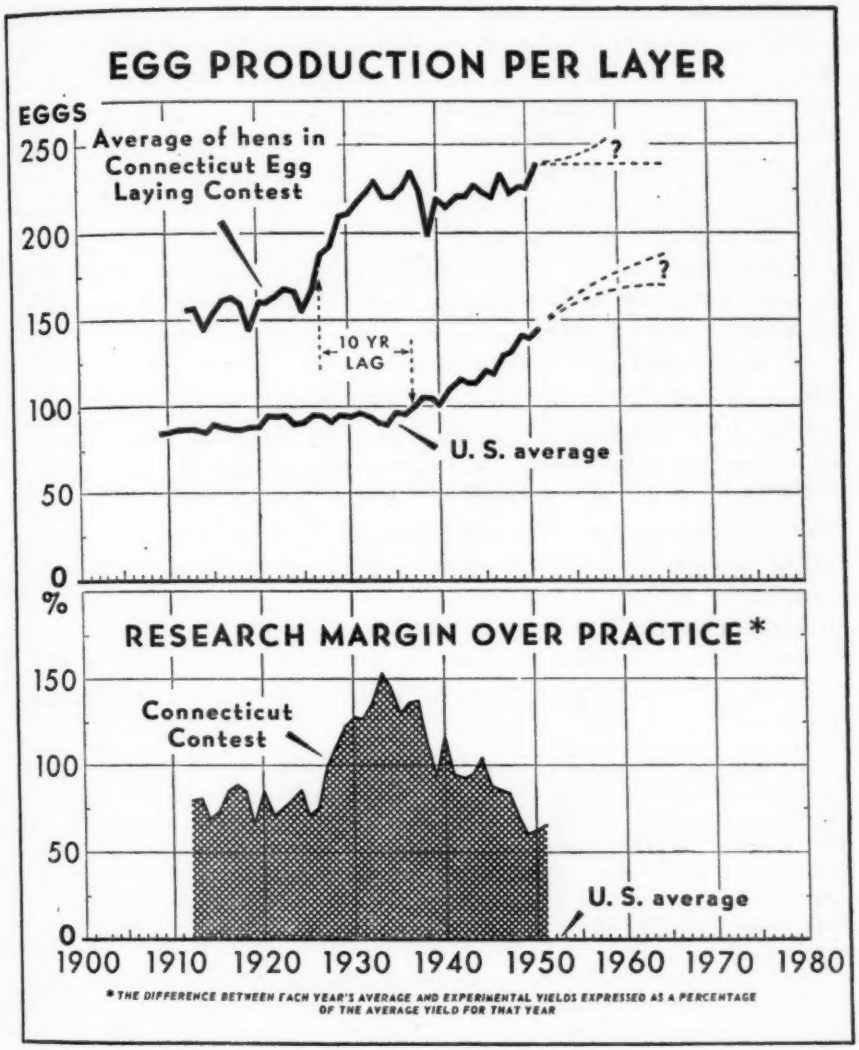

FIGURE 2

is seen to be even further delayed. Actually we know that most of the shift to hybrid varieties took place in Iowa during the period 1933 to 1944. Similarly, Figure 2 shows a 10 year lag between the upward climb of egg production per layer under test conditions and that for the U. S. as a whole. Preliminary work to date in ARA would indicate great variability in the time needed for a significant research result to reflect itself in practice. Additional work now being done with the agricultural experiment stations based on more commodities in more localities should provide

important clues regarding time lag and the factors responsible for it.

One factor of significance emerges from nearly all the preliminary work done in ARA to date—as production per acre and per animal pushes upward, it is increasingly difficult to sustain the higher level of production. The ravages of insects, diseases, and weather extremes require greater expenditures for research to protect or maintain the production levels. Still higher production is achieved only when additional research findings raise the ceiling on production possibilities.

In summing up their article, Cochrane and Lampe tend to dwell on the modest pressure of food supplies on demand that they foresee in their Situation II which assumes continued peacetime prosperity. Situation I, which more closely approximates the present condition of chronic hot and cold wars, they dismiss with the following sentence:

"This analysis indicates that the current concern over possible food shortages for the long run in the United States is unfounded, *except under conditions of continuing war or threat of war.*" (Italics Ours)

While we all hope for peace and prosperity, there is little in the current outlook to make this situation more likely in the next 20 years than continuation of present uncertainties. A rational government must need give as much consideration to the one situation as the other. Furthermore, we hope this can be done without too much implication of Malthusian overtones. The closing paragraphs of Dr. Shaw's paper states the position as follows:

"None of us is concerned about the people of this country going hungry in the foreseeable future. The nation has many alternative courses to pursue to prevent this eventuality. When economic and other conditions warrant, we can bring in more land than is now contemplated. Of even greater significance, when absolutely necessary we could move toward direct human consumption of plant products. Our concern, however, relates to maintaining and improving current diets with ample provision for livestock products and at costs that all our people can afford.

"It would seem that a favorable position for the nation would be one in which new research findings were being developed at a rate equal to or preferably greater than the rate at which current findings were being put into use. We would then have at all times some unused potential that could be called upon in an emergency. We would have also more assurance of meeting the nation's needs as population increases."

When the exception made in Cochrane and Lampe's summary paragraph is given greater weight, another point might be made. It is that in taking into account such a contingency, technical knowledge would be less costly to store and draw upon in the event of war than to store commodities and draw upon stocks.

In any event, technological advances are unlikely to be introduced in

agricultural production unless or until there is economic incentive to do so. They usually require capital investment, even where the aggregate resources used per unit of output are less, and farmers are unwilling to make this investment until the prospects for profitable returns are favorable. If this point, which is amply substantiated by Cochrane's analyses and observations in his progress report No. 50, as well as in his earlier provocative study, "Farm Price Gyrations—An Aggregate Hypothesis," Journal of Farm Economics, Volume 29, page 386, is borne in mind and the assumption of an automatic introduction of technological advance is eliminated, the situation outlined in Cochrane and Lampe's Situation II and portrayed in their Figure 3 would be considerably altered. They might in their analysis have alluded to the price situation that would occur with a supply curve more closely approximating that of 1951 and a 1975 demand curve. This would have led to quite different conclusions or perhaps more complete assumptions with respect to what would be necessary to assure the introduction of technological advances at an average annual rate comparable with that realized between 1910 and 1951.

It is curious that Professor Cochrane gave so much less emphasis to the nature of this "dynamic variable, farm technological advance," in his article with Lampe than he did in his critical note appearing in the same issue of the Journal (see pp. 280-281), "Professor Schultz Discovers the Weather."

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A REJOINDER

Drs. Trelogan and Johnson have the job of promoting and administering research whereas we have the job of investigating and measuring economic relations; hence we view the process of farm technological advance from a different vantage point than they. In case there is any question, we do not suggest that technological developments occur automatically or that their farm adoption is a down hill pull. But we do believe that powerful forces exist for overcoming the obstacles to farm technological advance and that factor productivity in agriculture will continue its upward trend at an unslackened pace. Among those forces we would list: (1) the "curious faith" of the American people in technological advance will yield the required financial support; (2) men like Trelogan and Johnson and many, many other technicians across the land will do their job so well that the new technologies will be forthcoming and (3) the prosperity postulated under

Situations I and II[1] would be sufficient to induce farmers to invest in the new technologies. Thus we are inclined to predict a continued rapid rate of technological advance on farms whereas Trelogan and Johnson are inclined to worry over the responsibility that they bear.

WILLARD W. COCHRANE
HARLAN C. LAMPE

[1] The Nature of the Race Between Food Supplies and Demand in the United States, *This Journal*, May, 1953.

A DEMAND CURVE FOR COMMERCIAL DAIRY FEED IN NORTHEASTERN PENNSYLVANIA

THIS note presents an illustration of the empiricizing of a theoretical demand curve. Specifically, the question to which this note is addressed is this: Does the short-run demand curve for commercial dairy feed provide an accurate schedule of quantities of feed purchased by specialized dairy farmers in the Northeastern Dairy Area of Pennsylvania in the period of 1941-44?

The short-run curve in question was derived from the theoretical formulation that the demand curve for a productive service is equal to the curve of the values of the marginal product of that service. The empirical data were taken from a study of the output responses of farm firms.[1]

In that study data from 15 single-enterprise dairy farms in Northeastern Pennsylvania were synthesized into a representative farm, typical as regards size, organization and practices. All costs other than purchased concentrates for cows were considered "fixed." The really important variable input of the area, grain fed to cows, was classified as the only variable. It was assumed that all the grain fed was purchased, which closely approximated the actual situation. The physical relationship between inputs of commercial dairy feed and the outputs of milk (4 per cent F.C.M.) per cow was based on an input-output investigation conducted by the U. S. Department of Agriculture and 10 State Experiment Stations.[2] The short-run cost structure of the representative farm was derived from this product curve and the factor cost data. The operating position of the representative farm was then compared with the point of maximum profit, or minimum loss. This procedure was followed for three consecutive 12 month periods, with accounting periods beginning May 1, 1941, 1942 and 1943, respectively. In two of the accounting periods the opti-

[1] W. W. Cochrane and W. T. Butz, "Output Responses of Farm Firms," *This Journal*, November 1951.

[2] Einar Jensen *et al.*, *Input-Output Relationships in Milk Production*, U. S. D. A. Technical Bulletin No. 815, May 1942.

mum level of output varied from the observed level by less than one per cent, whereas during the 1942-43 interval, the predicted output was approximately four per cent less than the actual (observed) output.

To obtain the short-run demand schedule of the representative farm for this productive service (20 per cent commercial dairy feed), the marginal physical products (column 3, Table 1) were derived from the production function (columns 1 and 2) of the above study. Applying the product price (column 4) to the marginal products, values of the marginal products were obtained (column 5). This schedule of values for 1941-42, shown in Figure 1, demonstrates graphically the relationship between value of marginal product and quantity of feed purchased. This is the derived demand curve for commercial dairy feed per cow of a representative single-enterprise dairy farm in Northeastern Pennsylvania in the period 1941-42. Similarly, the demand functions for the 1942-43 and 1943-44 periods were constructed. The position of the three curves indicates that demand "shifted" to the right through time due to the rising price of milk during this period.

Theoretical Demand Curves

Since the representative farm had an average of 13.3 cows for the accounting periods, the demand curves for the farm would be obtained by multiplying the quantities of feed by 13.3. The representative farm is assumed typical for specialized farms in the Northeastern Dairy Area of Pennsylvania, so the demand curve of the representative farm could be considered as typical of this type of farm in this area. Using the arc elasticity concept, the elasticity around the observed level of operations was found to be between -0.6 and -0.7 for each of the accounting periods.

With the theoretical demand curves formulated, the accuracy of these predictive instruments could then be measured. This was done by comparing the quantities of feed which the theoretical demand curves predicted would be purchased with the observed quantities purchased (as determined from the empirical data).

Quantities of feed purchased were measured in units of 133.3 pounds. This unit measure was used since in the physical input-output experiments the inputs were measured in Total Digestible Nutrients, and to obtain 100 TDN's from concentrates, 133.3 pounds of concentrates must be fed. Thus, during the 1941-42 period, when feed was priced at $2.14 per hundredweight, the cost of 133.3 pounds of feed was $2.85. In 1942-43, the cost was $3.32, and 1943-44, $4.19 per 133.3 pounds of feed.

The curve for the 1941-42 period demonstrates that at a price of $2.85 per 133.3 pounds of feed, the typical specialized dairy farmer in the area would purchase 1,888 pounds of feed. The empirical data indicated that

TABLE 1. DERIVATION OF THE VALUE OF THE MARGINAL PHYSICAL PRODUCT PER COW OF PURCHASED FEED USED IN THE PRODUCTION OF 4 PER CENT MILK ON A REPRESENTATIVE, SINGLE-ENTERPRISE, NORTHEASTERN PENNSYLVANIA DAIRY FARM, 1941–42*

(1) Quantity of the productive service	(2) Total physical product	(3) Marginal physical product	(4) Price of the product	(5) Value of the marginal product	(6) Price of the service	(7) Total cost of the service	(8) Fixed cost	(9) Total cost	(10) Total receipts	(11) Net profit or loss
(Cwt. of feed)	(Cwt. of 4% milk)	(Cwt. of 4% milk)	(Dollars per cwt. 4% milk)	(Dollars per cwt. feed fed)	(Dollars per cwt.)	(Dollars)	(Dollars)	(Dollars)	(Dollars)	(Dollars)
9.84	55.82	1.69	2.49	4.21	2.14	21.06	136.09	157.15	138.99	−18.16
11.17	57.41	1.59	2.49	3.96	2.14	23.90	136.09	159.99	142.95	−17.04
12.50	58.91	1.50	2.49	3.74	2.14	26.75	136.09	162.84	146.67	−16.17
13.84	60.33	1.42	2.49	3.54	2.14	29.62	136.09	165.71	150.22	−15.49
15.17	61.67	1.34	2.49	3.34	2.14	32.46	136.09	168.55	153.56	−14.99
16.50	62.94	1.27	2.49	3.16	2.14	35.31	136.09	171.40	156.72	−14.68
17.84	64.14	1.20	2.49	2.99	2.14	38.18	136.09	174.27	159.71	−14.56
19.17	65.27	1.13	2.49	2.81	2.14	41.02	136.09	177.11	162.54	−14.57
20.50	66.34	1.07	2.49	2.66	2.14	43.87	136.09	179.96	165.19	−14.77
21.84	67.36	1.02	2.49	2.54	2.14	46.74	136.09	182.83	167.73	−15.50
23.17	68.31	.95	2.49	2.37	2.14	49.58	136.09	185.67	170.09	−15.58
24.50	69.22	.91	2.49	2.27	2.14	52.43	136.09	188.52	172.36	−16.16
25.84	70.07	.85	2.49	2.12	2.14	55.30	136.09	191.39	174.74	−16.65
27.17	70.88	.81	2.49	2.02	2.14	58.14	136.09	194.23	176.49	−17.74
28.50	71.64	.76	2.49	1.89	2.14	60.99	136.09	197.08	178.38	−18.70
29.84	72.86	.72	2.49	1.79	2.14	63.86	136.09	199.95	180.18	−19.77
31.17	73.04	.68	2.49	1.69	2.14	66.70	136.09	202.79	181.70	−21.09
32.50	73.68	.64	2.49	1.59	2.14	69.55	136.09	205.64	183.46	−22.18

* Price and cost data for 1942–43 and 1943–44, respectively, were as follows: Price of the product—$2.88 and $3.49; Price of the service—$2.49 and $3.14; Fixed costs—$137.67 and $135.85.

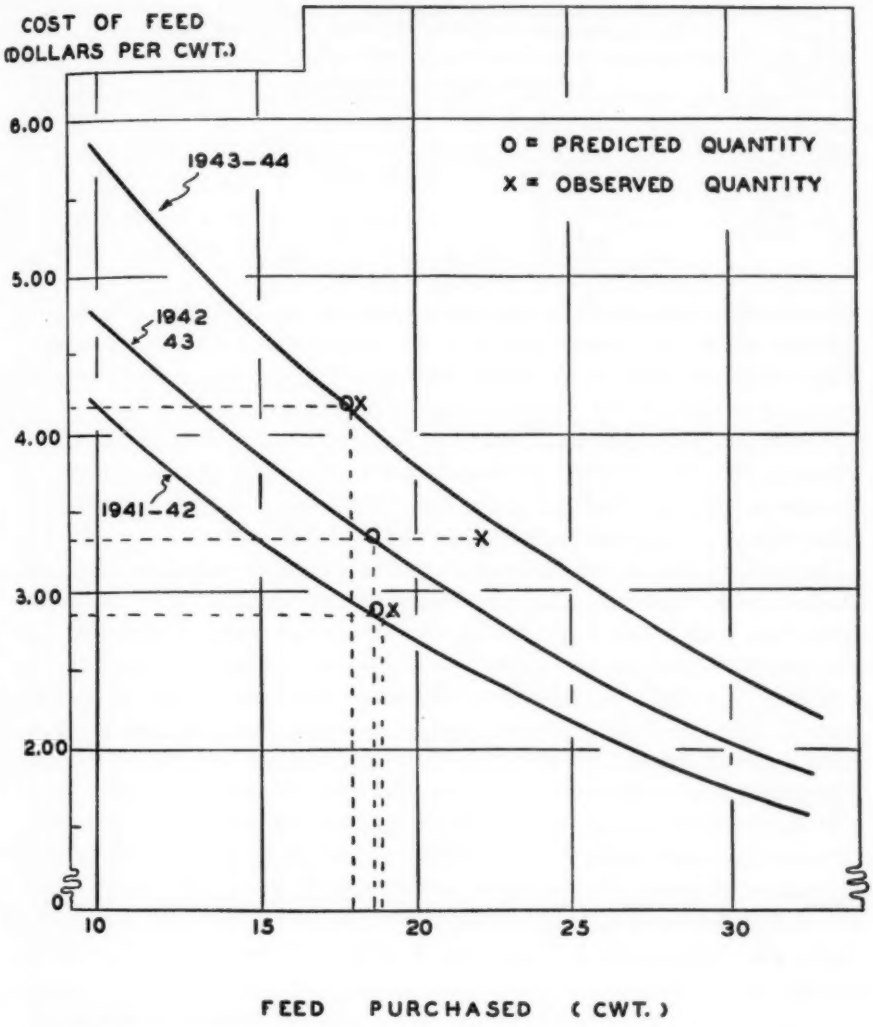

FIG. 1. SHORT-RUN DEMAND CURVES FOR 20 PERCENT DAIRY FEED, PER COW, REPRESENTATIVE FARM, NORTHEASTERN PENNSYLVANIA, 1941-44.

he purchased 1,957 pounds, or 3.5 per cent more than the quantity predicted. Observed and predicted quantities purchased are presented in Table 2 and are shown graphically in Figure 1.

While the deviations of predicted from observed quantities are relatively slight in the 1941-42 and 1943-44 periods, the deviation is greater in 1942-43. No ready explanation can be made for this variation, although two possible explanations can be advanced: (1) the producer may have

TABLE 2. QUANTITIES OF COMMERCIAL FEED PURCHASED, OBSERVED AND PREDICTED, REPRESENTATIVE FARM, 1941–42, 1942–43 AND 1943–44

Period	Quantities of feed purchased		Deviations of predicted from observed quantities
	Observed	Predicted	
	(pounds)	(pounds)	(per cent)
1941–42	1,957	1,888	− 3.5
1942–43	2,212	1,871	−15.4
1943–44	1,798	1,784	− 0.8

been unduly influenced by the rising price of milk to expand milk production while not considering that the nearly equal rise in the cost of feed would not warrant an output increase; (2) the producer may have responded to appeals for expanded war-time efforts.

It will be noted that in all three periods the predicted quantity of feed was less than the quantity of feed actually fed. While this condition may be due to uncontrolled factors in the experimental design, a partial explanation may be found in the type of physical data used.[3]

In light of the above data, the conclusion appears justified that the theoretical formulation was a reasonably accurate instrument of prediction—that within this framework is found one plausible explanation for purchases of feed by specialized dairy farmers in the area studied.

It may be noted that the above illustration can be construed as another way of looking at the optimum output position of a firm, inasmuch as both methods are based on the assumption that a firm will continue to add productive units as long as they add more to receipts than to costs. Just as the entrepreneur in a competitive firm will add units of productive services until receipts equal costs, so the entrepreneur will demand quantities of productive services until receipts from the service equal the cost of the service. As shown in this study and in the output response study, this assumption is supported at least in these restricted areas of testing.

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[3] The Jensen *et al.* study attempted to vary the inputs of TDN mainly by varying the amount of concentrates fed. However, the amount of forage consumed decreased somewhat as the level of grain fed increased, giving rise to the possibility that the expansion in grain intake was partially offset by a contraction in the amount of forage consumed. Thus the marginal physical product tends to be that of the net intake increase of feed (grain less roughage) rather than of the grain itself. Since the MPP of the increase in TDN intake from feed (grain less roughage) is less than the MPP of the grain itself, the height of the demand curves—and thus the location of the predicted quantities—is underestimated. Lack of empirical evidence, however, prevents any measure of this variation.

PRICE SUPPORT SEMANTICS

MANY of the disputes in the world arise over words," according to Lord Mansfield, eighteenth century English judge. Disputes over farm price policy involve, increasingly it would seem, the meanings and usages of words. Agricultural economists understandably try to refrain from pure disputation, but are nevertheless exposed to the word barrage, and will be fortunate if their own discussions do not lapse occasionally into the territory which has been posted by the semanticists.

So clearly has some of this territory been posted by semanticists that, given but a cursory examination of their work, our ability to discern the posted areas in our own field can be much improved. To illustrate this point, a few brief applications of the principles of semantics to the field of farm price policy have been selected.

The semanticist knows how easy it is to become "intensionally oriented"; i.e., to fall into the habit of guiding ourselves by words alone (as distinct from "extensionally oriented"; i.e., governed by the facts of observation and the facts to which words guide us). Recognizing (and studying) as he does, the power of words, he knows the value of classifying and giving names to things or concepts. He has therefore developed a broad nomenclature which includes, in addition to "intensional orientation," a number of other terms which it is useful for us to know. Perhaps the best known concept of the semanticist is "two-valued orientation"; i.e., an orientation which implicitly involves the assumption that each question has only two sides. Everything resolves into good and evil, or black and white, or Republican and Democratic, to one so oriented—dichotomizing, either you're with me or you're against me. We are aware of the fact that the Republican-Democratic dichotomy has virtually no meaning in the context of farm price policy, but that instead a farm state-industrial state dichotomy is reflected in the voting. The following breakdown of the votes (1952) in the lower house of Congress on the extension of mandatory supports illustrates which is the pertinent two-valued orientation:

	For	Against	Not Voting
Northeast[1] (predominantly industrial states)	15	95	17
Schizoid States[2] (industrial states with very important farm segment)	42	35	12
Midwest farm states[3]	51	4	9
West[4]	21	2	3
South[5]	93	0	33

[1] Conn., Del., Me., Md., Mass., N.H., N.J., N.Y., Pa., R.I., Vt.
[2] Calif., Ill., Ohio, Mich.
[3] Ind., Iowa., Kan., Minn., Mo., Neb., N.D., S.D., Wis.
[4] Ariz., Colo., Idaho, Mont., Nev., N.M., Ore., Utah, Wash., Wyo.
[5] Ala., Ark., Fla., Ga., Ky., La., Miss., N.C., Okla., S.C., Tenn., Tex., Va., W.Va.

We may be less aware, however, of some of the more subtle manifestations of the two-valued orientation. Take the following two pairs of words for example:

Rigidity-Stability
Flexibility-Volatility

"Rigidity" is what the semanticist might call a "snarl" word meaning "stability," which might be called a "purr" word. Likewise, "volatility" is a snarl word meaning "flexibility," which is a purr word. Left to the free market, many farm prices are so volatile as to impair the allocative function by obscuring the signals which the farmer is supposed to receive from the marketplace. Whatever adjustments the consumers' scales of preference may be undergoing—the price changes which the farmer observes may in no way reflect these adjustments. Moreover, even if he could know what the consumer wants, he cannot know what other producers plan to do about it. When there has been considerable "snarling" about volatility and "purring" about stability, measures are taken to stabilize farm prices. Stability has a way of becoming rigidity, however, and "snarling" about rigidity involves "purring" about flexibility. Logically, this resolves itself into a ping-pong game in which each time one espouses flexibility, an opponent charges volatility; and each time one espouses stability, an opponent charges rigidity. Fundamentally one side is saying "Either we have price supports or volatility; so we must have price supports," while the other group reasons "Either we have a free market or rigidities; so we must have a free market." The underlying two-valued orientation is between *price supports* and a *free market,* recognizing no intermediate possibilities and being careful to label that which is not wanted with the appropriate "snarl" word and that which is wanted with the appropriate "purr" word.

Another area which has been posted by the semanticists has to do with polar terms—terms which have no meaning of themselves, but require an opposite as a frame of reference. What are "high" price supports, for example? Strictly speaking, all that we can say is that they are not "low." But clever use of the polar term "high" has succeeded in inducing a "signal reaction" from most of us such that we say "high" price supports are supports at 90% of parity or above. Meanwhile, the parity ratio has dipped to the dangerously "*low*" level of 92%! Furthermore, to counteract the success that some have had in establishing a signal reaction to the term "high rigid" price supports, others have fallen back upon the two-valued orientation to imply that who opposes high rigid supports opposes supports.

In addition to "intensional orientation," "two-valued orientation," "snarl"

and "purr" words, "signal reaction," and "polar" words, there are other terms employed by semanticists which are helpful in guarding against "word tyranny" in its various manifestations. "Family farm," for example, is a phrase notable for its "affective connotations"; i.e., its utterance has more to do with feelings than with information. It borders on being a "directive utterance" in a class with "The American Way." Many of the terms which are technically defined may nevertheless carry subtle affective connotations: "basic" and "non-basic" crops (two-valued orientation?), "parity" (purr word?), "subsidy" (snarl word?), and "free market" (directive utterance?).

The words in this note which are used in semantics are just like the words which are used in our own field. They are only words, and should be treated as such. If they are used to guide us to facts, they can help us solve problems. If not, they will add to our problems. This note is an appeal to look toward some of the unfamiliar concepts of semantics as a means of keeping the familiar terms of agricultural price policy as reliable guides. A most appropriate conclusion is provided in the concluding paragraph of an article in the last issue of this Journal, in whcih article the two-valued orientation as it applies to freedom and security is exposed.

"Public policy analysis, to be meaningful, must deal with specific appraisals of the entire array of consequences to flow from alternative courses of action. It must not be fabricated upon slogan, shibboleth or sweeping generalization, nor based upon drastic oversimplifications of the nature of social-economic organization. Glittering generalizations, such as the one discussed in this note about the inherent incompatibility of security and freedom, may be attractive to politicians but social scientists must be careful not to mistake the glitter for gold."[1]

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[1] Erven J. Long, "Freedom and Security as Policy Objectives," *This Journal*, August, 1953, page 322.

A FOUR-EQUATION MODEL OF THE FEED-LIVESTOCK ECONOMY AND ITS ENDOGENOUS MECHANISM— A CORRECTION

MR. J. VAN IJZEREN of the Netherlands Central Bureau of Statistics has kindly pointed out a simpler method of obtaining the roots and some apparent computational errors in the article "A Four-Equation Model of the Feed-Livestock Economy and its Endogenous Mechanism," published in *This Journal*, February 1953, pp. 44 ff.

If the determinantal equation is written in the determinant form, as

shown on page 52 of the original article, the upper and middle row can be divided by $x^2 - 1$. Hence the determinantal polynomial has $(x^2 - 1)^2$ as a factor. Division of the polynomial by this factor gives

$$x^3 + 0.1394x^2 - 0.9361x + 0.1531 = 0.$$

Solution of this cubic equation by the usual method gives the roots 0.1736, 0.7955, and −1.1085. Thus the 7 roots of the determinantal equation are 1, −1 (both double) and the three roots of the cubic equation. As these differ from those in the original paper, a computational error was indicated.

Checking of the computations indicated an error in obtaining the first term of f_2. Computations involving f_3 and subsequent steps would need to be revised accordingly. As before, f_6 turns out to be close to zero and, when the steps indicated at the bottom of page 55 and the top of page 56 are followed, the remainder after dividing $f(x)$ by f_5^2 turns out to be exactly zero to 5 decimals. This result is more consistent with expectations than that given previously. The cubic equation resulting from this computation is identical with that given above.

In making these revisions, the computations first were carried to 4 decimals, as in the original paper. As the results from applying Sturm's theorem did not check with those obtained from the direct solution, the computations were made carrying 8 decimals. The results from these two computations and from the direct solution are indicated in Table 1.

The discrepancy between these results can be explained as follows: If f_6 is identically equal to zero (as indicated by the direct solution and to 3 and 7 decimals, respectively, by the computations involved in connection with Sturm's theorem), then f_5 divided by f_6 is undefined and f_7 does not exist. Thus the last two sign changes (see page 54 of original article) should be omitted when applying Sturm's theorem. When this is done for the revised computations, each of the solutions indicates 2 roots between $-\infty$ and 0 and 3 roots between 0 and $+\infty$.

The conclusions with respect to the nature of the endogenous mechanism for this system of equations are essentially the same as those given previously. Since some of the roots are negative, the system may involve one-period oscillations which alternate between "high" and "low" values for successive periods. (The solution given previously indicated cyclical fluctuations [complex roots] rather than one-period oscillations.) Since at least one of the roots is greater than unity in absolute value, the time paths of the variables involve oscillations of ever increasing amplitude. Moreover, double roots, even if their absolute value does not exceed unity, can give "exploding" terms in the solution of difference equations. Since

TABLE 1. RESULTS OF APPLYING STURM'S THEOREM WHEN COMPUTATIONS ARE CARRIED TO 4 DECIMALS AND TO 8 DECIMALS IN RELATION TO THOSE OBTAINED BY A DIRECT SOLUTION

Value of x	Variations in sign when carrying—		Number of roots between value of x and zero		
			When carrying—		Direct solution
	4 decimals	8 decimals	4 decimals	8 decimals	
$-\infty$	6	6	3	1	2
0	3	5	—	—	—
∞	1	1	2	4	3

none of the roots is very much greater than unity, any explosive tendencies of the system probably will manifest themselves slowly.

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THE USE OF LONG-RUN PRICE FORECASTS IN FARM PLANNING[1]

TWO sets of data are needed in farm planning—data showing input-output relationships in physical terms, and price-cost data. For the farmer, the prices which are relevant in decision making are those which he expects to pay for input items at the time they are bought, and the prices which he expects to receive for his products at the time they are sold. If the farmer is considering adjustments in his farm business for the coming year, prices which are expected during the year ahead are applicable. If an attempt is being made to estimate the most profitable basic resource and enterprise organization to serve as a guide for say five to ten years, prices which are expected during the five to ten-year period are relevant. Past or current prices are relevant only as a starting point in formulating expectations regarding future prices.[2]

In selecting prices for use in farm planning, the most important problem is generally believed to be the establishing of the proper relationships among the prices of the various products. If the relationships among prices were forecast accurately, correct conclusions could be drawn re-

[1] Journal Article No. *1539* of the Michigan Agricultural Experiment Station. Part of the discussion in this note was taken from a broader study of farm planning presented in the writer's Ph.D. thesis, *Application of the Budget Method in Farm Planning*, Harvard University, 1953.

[2] Probably no one has more persistently urged the importance of using future prices in production planning than John D. Black, most recently in *Introduction to Economics for Agriculture*, The Macmillan Co., New York, 1953, p. 156.

garding the relative profitability of alternative plans, even though the forecast regarding the *level* of prices proved to be inaccurate. For this reason, many agricultural economists have argued that only price relationships are relevant, and that the price level can be ignored. Now, in the first place, if a forecast of price relationships is made very explicit, it in fact amounts to a forecast of the price level at the same time. For instance, if we forecast that in the coming year hog prices are going up ten percent while beef cattle prices are going down five percent, we can very easily deduce the price levels by adding ten percent to the current year's hog prices and by subtracting five percent from cattle prices, since the current year's prices are usually a historical fact at the time the forecasts are made.

In the second place, there are certain advantages to making the best possible forecast of the price level. First is the psychological value of having the price level as realistic as possible. For example, in the Missouri Balanced Farming program, 1925-39 prices were used in estimating farm earnings until 1951. In an evaluation of the Missouri program by D. D. Brown, a sample of county extension workers was asked to report the major problems involved in using the Balanced Farming approach, and to rank the problems in the order of their importance.[3] Fourteen problems were reported, and the one which was ranked first in importance by the county workers was "inadequate price and cost data," partly because of the unrealistic price level farmers were asked to use, and partly because prices and costs on more items were needed. A second advantage of forecasting the level of prices is that the resulting estimates of farm earnings may influence the farmer's choice of alternatives. For instance, under any likely set of price relationships, net earnings on many farms in the Lake states will be higher with a dairy herd than with a beef-cow herd. However, if a farmer estimated that he could obtain sufficient income from a beef-cow herd to satisfy his family's needs under prospective prices, he may quite nationally choose this alternative and forego the opportunity of higher earnings with a dairy herd. A third advantage of estimating the price level as closely as possible is that it makes possible a realistic estimate of net earnings which is useful in determining capital requirements, in planning family expeditures, and in scheduling debt repayments.

It should be pointed out that some assumption must be made concerning prices regardless of the planning method used. This is also true whether the farmer is making a decision on his own, or whether the farm management specialist is formulating a recommendation for him. Con-

[3] Dorris D. Brown, *Problem Solving in a Farm and Home Planning Teaching Program*, Harvard DPA thesis, 1952, Chapter V.

sciously or unconsciously, the decision-making process involves some estimate of future prices. In the informal methods of planning, however, it is possible to arrive at a conclusion without making the forecasts explicit. For example, a reasoning process such as the following can be followed: "Sugar beet prices are expected to rise less than the prices of other crops; therefore, it will be relatively less profitable to grow sugar beets than it was in previous years." On the basis of this reasoning concerning prices, along with other considerations, it may be concluded that sugar beets should be eliminated from the cropping program without ever predicting specific dollars-and-cents figures for the prices of sugar beets or for competing crops. In the more formal methods of planning, the physical volume of products available for sale is estimated and multiplied times expected prices to obtain the estimate of gross earnings. A similar procedure is used in analyzing the cost side of the net-earnings estimate. In such cases there is no alternative to making the price forecasts explicit.

While most agricultural economists agree that forward prices are appropriate in farm planning, in few cases have actual forecasts been made. The usual procedure both in farm management research and in extension farm planning has been to use present prices or some series of historical prices. The historical series chosen is usually an average of several recent years, or the average prices which prevailed during a period which is considered as "normal," such as 1935-39. *It is not always certain that those using a historical series are aware that in selecting these past prices, they are implicitly predicting that these prices will prevail in the future period.*

Forecasting Agricultural Prices and Costs for 1960.[4]

The decision to make and use price forecasts in a farm planning program must be based on two assumptions: (1) that the economist's best appraisal of future prices will be superior to using current or historical prices, and (2) that these price forecasts will be of help to the farmer in formulating his own price expectations in production planning. Accepting these two assumptions as valid, the writer has forecast a set of prices and costs which he believes are appropriate for use in long-run (five to ten years ahead) farm planning in Michigan.

It was decided to center the forecast on the year 1960 in order to facilitate the use of basic forecasts which the Bureau of Agricultural Economics and other analysts have made for the decade of the 1950's. For several years from the time this analysis was made, the year 1960 will be

[4] The writer is indebted to L. L. Boger, price analyst at Michigan State College, for his assistance in the over-all price analysis, and to the commodity marketing specialists at Michigan State College for their help in establishing the relationships among commodities.

representative of the length of run which is involved in long-term farm planning. The projections were made in mid-1952, using advance estimates of given data for 1952 as the base. The following data, based on reports of the Departments of Agriculture and Commerce, were taken as given:

1. A total national population of 155 million.
2. A total national income of $285 billion.
3. A total national net farm income of $18.8 billion.
4. An average index of 295 for prices received by United States and Michigan farmers.

The following assumptions were made for the period 1952-60, or for the year 1960:

1. That no all-out world war will occur, but that world peace will be so insecure that a high rate of government spending for defense will be maintained in the United States, and that armed forces will be maintained at around 3.5 to 4.0 million men.
2. That high expenditures by the United States government combined with public pressure for lower taxes will result in an average annual government deficit of $5 billion.
3. A marginal propensity to consume, for the United States population as a whole, of one-half, with a resulting multiplier of two.
4. Continuation of the present high birth rate and the present mortality rate in the United States.
5. That average or normal weather will prevail in the United States.
6. An aggregate price elasticity for farm products of −.25 in the United States.[5]
7. That total net farm income in the United States will contribute the same percentage of the total national income as it has in recent years (about 6.7 percent).
8. That during the future period, Michigan farm prices will bear essentially the same relationship to United States farm prices as they have during the period since 1910.

With the basic data and assumptions outlined, the analysis proceeded as follows. It was estimated that total national income would be $365 billion by 1960, if there were no increase in population. This is the inflationary increase in national income which follows from the assumption of a $5 billion annual deficit, a multiplier of two, and a consequent increase in national income of $10 billion per year during the next eight years. This would give a per-capita income of $2,400, based on present

[5] This elasticity has frequently been used in farm price analysis. For example, see T. W. Schultz, *Economic Organization of Agriculture*, McGraw-Hill Book Co., New York, 1953, Table 11.

population. It was then assumed that this per-capita income would apply to the increased population of 1960.

Forecasts of population for 1960 by various demographers were studied, and a total population of 179 million by 1960 was selected as most probable. Applying the per-capita income rate of $2,400 to the total population of 179 million gave an estimate of $430 billion total national income for 1960.

The original assumption that farm income was expected to be approximately 6.7 percent of total national income produced an estimate of $28.8 billion for net farm income. This is a $10 billion, or 53 percent, increase over the estimated 1952 level. With the increase in population and national income forecast, it was predicted that agricultural production (after allowing for net exports) would increase about 1.5 percent per year, or about 12 percent between 1952 and 1960. If the price elasticity for farm products were −.25 as assumed, the increase in agricultural production would have a 48 percent depressing effect on farm prices. This depressing effect balanced against the 53 percent upward pressure exerted by the increase in farm income results in an estimate of a 5 percent increase in prices received by United States farmers. This would put the index of United States prices received at 310 in 1960. It was assumed that the parity ratio would be slightly under 100 in 1960 –perhaps at 97, which would give an index of prices paid of 320.

The relationship between Michigan and United States prices was established by correlating the annual indexes of Michigan and United States farm prices. Simple linear correlation analysis produced the following values: $r = -.992$, $r^2 = -.984$, and an estimating equation of $y = 3.36 + 1.01x$, where y is the index of Michigan farm prices and x the index of United States farm prices. Use of this equation yields an estimate of 316 for the index of Michigan prices received for 1960. An index of prices paid is not available for Michigan, so it was assumed that there is no essential difference between Michigan and United States prices paid. The final indexes indicate a 7.0 percent increase in Michigan prices received and an 8.5 percent increase in prices paid by 1960.[6]

[6] The assumption regarding war or peace in this analysis corresponds to Situation No. 1 of chronic hot and cold wars postulated by Willard W. Cochrane and Harlan C. Lampe in "The Nature of the Race Between Food Supplies and Demand in the United States, 1951-1975," *This Journal*, May 1953, pp. 203-222. The following comparisons are also of interest (the writer's assumptions first, followed by those of Cochrane and Lampe): −.25 price elasticity for farm products vs. −.235 for food at retail; high rate of population growth versus medium; 1.5 percent annual increase in agricultural production vs. 1.1 percent. Cochrane and Lampe do not make a prediction of long-run prices, but their projections appear to be comparable to those of the writer after making allowances for the difference in time period and the factors militating against the extreme rise in projected prices pointed out by the authors on pp. 219 and 220.

After the levels of farm prices and costs had been forecast, the next step was to establish the relationships among prices. Current and historical series of prices and costs for Michigan were compiled to serve as bases in establishing the relationships and in making the individual projections. Commodity marketing specialists at Michigan State College provided assistance in making the projects for individual products. The price series, the given data, assumptions, and forecast of the over-all level of farm prices and costs as outlined above were presented to the specialists.

With this information in mind, the specialists made tentative forecasts regarding percentage changes in prices of the various farm commodities produced in Michigan. In making these projections, factors such as the following were analyzed: trends in consumption demand, demands for feed and export, livestock production and price cycles, normal bearing life of fruit trees, prospective technological developments affecting yields and rates of production, and any unusual factors affecting the current prices of products. After obtaining the predictions from the commodity specialists and noting the major shifts anticipated in price-determining factors, the farm product prices were projected for 1960. The index of Michigan farm prices was computed for the projected prices, and adjustments made until the index approximated the level of 316. The final projections called for decreases in the prices of cattle from levels which were current in the early part of 1952, little changes or slight increases in the prices of sheep, poultry, eggs, and most grains, and relatively larger increases of 12 to 15 percent for hogs and dairy products. Altogether, the prices of 48 farm product items was projected. The forecasts for seven major products grown in Michigan are shown in Table 1 along with selected historical comparisons.

TABLE 1. PRICES RECEIVED BY MICHIGAN FARMERS FOR FARM PRODUCTS SOLD, 1935–39, 1947–51, AND PROJECTED FOR 1960

	Unit	1935–39	1947–51	Projected 1960
Corn	bu.	$ .70	$ 1.62	$ 1.83
Field beans	cwt.	3.10	8.45	7.34
Potatoes	bu.	.78	1.38	1.43
Sour cherries	ton	61.00	165.00	149.00
Milk, blend, 3.5% butterfat, f.o.b. farm, Detroit milkshed	cwt.	1.46	4.04	4.90
Barrows and gilts, 200–220 lbs., Chicago	cwt.	9.51	22.58	24.67
Eggs	doz.	.22	.46	.51

A similar procedure was used in arriving at projections for 132 farm cost items. Farm cost projections prepared by the Bureau of Agricultural Economics for use in evaluating river-basin development programs were

used as a guide in establishing the relationships among the individual categories of farm cost items.

The writer believes that forecasts, such as the one presented here, can be of considerable help to farmers in choosing prices which they will use in making decisions regarding the future. It is not expected that such forecasts be adopted across-the-board by all farmers—but rather that the forecasts and the analysis upon which they are based be presented as the economist's best judgment of the future which farmers can weigh, along with other information, in formulating their price expectations. In this study, the prices were forecast and presented in terms of a single most-probable price. The usefulness of such forecasts to farmers would be increased materially by presenting a range about the most probable price or a probability distribution. In any case, under the real conditions of imperfect knowledge and foresight, farmers must modify the price forecasts in light of their own subjective evaluations of the future. The extent to which a farmer will discount future prices in planning depends upon the amount of uncertainty which he feels, his equity situation, his age and family status, and his subjective attitude toward risk.

It might be argued that it is the economist's responsibility to stay well on the conservative side in presenting price forecasts to farmers—in order to protect himself and the farmer from overly-optimistic forecasts which may not materialize. The writer believes that it is the responsibility of the economist to present the best possible evaluation which he can make of the future; the individual farmer, rather than the economist, is in best position to discount the future in the light of factors suggested in the previous paragraph. Furthermore, is it not possible that overly-conservative forecasts, if taken seriously by farmers, may do as much damage to their income situation as overly-optimistic forecasts? There is little doubt that the low price levels used by some lending institutions in estimating farm earning possibilities have restricted credit used by farmers beyond the amount which would have been profitable to both farmers and the lenders. Extreme conservatism during the World War II period led some farm advisors to caution against buying land, while other more realistic advisors were correctly suggesting the advisability of buying land and expanding farm operations.

Long-run price forecasts are useful in estimating the most-profitable basic farm plan, but the path through which prices are expected to move is also relevant in planning.[7] Even though average prices for the long-run

[7] Actual developments on the supply side of the analysis during 1952 were sufficiently different from those assumed as to deserve special mention. During the year, the rate of agricultural output in the U. S. increased about 3 percent. At the same time, U. S. agricultural exports declined approximately 30 percent. Since

period are satisfactory in estimating the basic long-time plan, the path of movement is important in outlining the steps to be taken in the transition from the old to the new plan, and in scheduling the major investments in a farm development program. In addition, the plan should be adapted to take advantage of any important up-swing within the period, and to provide adequate hedges and safeguards in case of a major down-swing. In addition to the long-run prices, annual forecasts would be helpful to farmers in their year-to-year planning, or in making annual adjustments in their basic plans. Various shorter-term forecasts would be relevant in making shorter-run decisions.

The method used in making the long-run price forecasts in this analysis illustrates one procedure which can be used in forecasting prices for use in farm planning. Other methods may have equal or greater validity in long-run price forecasting. Certainly no claim for precision in forecasting is made (such as might be implied by the precise figures in Table 1). Personal judgment necessarily entered into the analysis at various points. It is believed, however, that the conclusions reached follow logically from the given data and from the assumptions made. Obviously the prices forecast would not be expected to obtain if the assumption regarding peace or war does not materialize; for example, if either an all-out war or real peace should develop. The writer would expect to revise the forecasts as soon as such developments occurred, or as soon as other important new information became available. By following such procedures, it should be possible to provide farmers with realistic price data which will be superior to any series of historical prices which might be chosen.

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exports have been running at about 10 percent of total U. S. production, this means the decline in exports was equivalent to a 3 percent increase in agricultural output available for domestic consumption. The combined total gives a 6 percent increase in domestic supply, which resulted in a sharp decrease in farm prices during 1952.

HORTICULTURAL SPECIALTIES: A NEGLECTED SEGMENT OF U. S. AGRICULTURE

HORTICULTURAL specialties have seldom been considered in the thinking, planning, and formulation of farm policy in the United States. This condition has continued to prevail in spite of the proven importance of this kind of farm production to the agriculture of many States and counties.[1] There is some evidence of growing interest in these prob-

[1] M. Truman Fossum, *Trade in Horticultural Specialties 1890-1950,* Bureau of Agricultural Economics, Marketing Research Report No. 33, April 1953.

lems. The purpose of this report, addressed to the teaching, extension, and research personnel of agricultural economics, is to provide a better understanding of this segment of farm production and its difference from or similarity to those portions of the agricultural, manufacturing and marketing economy which have been studied in detail.

Terminology

In addition to flower, nursery, bulb and flower seed production the horticultural-specialty crop classification has included propagated mushrooms, greenhouse vegetables, vegetable plants, vegetable seed and specified small fruits such as blueberries. Up to the present time, sod, as a commercial item, has not been included. That portion of the horticultural specialties which does not pertain to food crops has often been known as ornamental horticulture (including floriculture) or as nurseries. Only in the broadest sense is this terminology applicable. Trade usage, in the United States, compels the acceptance of a more specific classification and nomenclature for the industry.

Production and distribution of the nonfood crops of the horticultural specialties is best known in the United States, as commercial floriculture and commercial ornamental horticulture. The distinction between the two is determined by use of the commodities rather than the plant names, production facilities or other criteria for classification. In the business of floriculture the cut flowers, plants or foliage are grown and sold primarily for decorating the interior of homes or other buildings and for personal adornment, whereas in the business of ornamental horticulture the plants are grown primarily for replanting out of doors. In most parts of the United States the term nursery, applies to establishments which grow and sell woody and perennial herbaceous plants and is thus a major component of ornamental horticulture.

Origin of the Industry

Prior to the twentieth century the nonfood crops of the horticultural specialties were an integral part of other kinds of farm production in the United States because a major portion of the business had to do with forest seedlings and fruit stocks for plantings on commercial and noncommercial farms. The development of what is now known as commercial floriculture and commercial ornamental horticulture arose from these establishments and private estate and public park gardening. Demand for the goods and services of commercial floriculture and commercial ornamental horticulture was enhanced by the exodus of large percentages of the population from rural surroundings to urban living.

Development of the Industry

In the United States the development of commercial floriculture and commercial ornamental horticulture during the first half of the twentieth century has been somewhat comparable to that of commercial farms arising out of the subsistence and barter kind of farming which was predominant in the pre-Civil War agriculture of the country.

Mechanization does not lend itself so readily to floricultural and ornamental horticultural crop production as it does to many other kinds of farm production. Moreover, the industry has been loath to recognize technological progress. Not the least of the reasons for this adherence to the hand methods of the past is the origin of the industry from the apprenticeship and cheap but skilled labor of private estate and public park gardening.

Perishability of the commodities provided other reasons for this industry to continue being centered around retail growers while the rest of agriculture progressed to commercial farming in which retail distribution became more generally separated from farm production and wholesale trade.

The most perishable of the horticultural-specialty crops are those of floriculture. Until recently, the producers of such crops tended to locate near to the consumers. This resulted in concentrations of such production in and near to the highly populated areas. But the adaptability of many floricultural commodities to air transport now for the first time enables producers to locate their production facilities for such crops with considerably less emphasis on distance to the consuming market areas.

Less perishability among many of the crops of ornamental horticulture permitted such producers to be further removed from the centers of population. A major exception to this tendency has been the production of large sized trees and shrubs for landscaping, which are bulky and costly to transport over long distances but the production of which requires acreages or areas which are necessarily further removed from cities than is incident to the intensive culture and practices for most greenhouse and outdoor flower crops. With the advent of the bulb and flower seed business the industry witnessed more complete separation from population centers and intermingling with other farms than was practical for the floricultural and specimen landscape items. Satisfactory transportation of bulbs and seeds has been of lesser importance than climate, soil and skilled labor requisites for production of the crops.

During and since the transition from forest seedling and fruit stock production early in this century the growers of floricultural and ornamental horticultural crops have been more highly specialized than any other kind of farm production. This tendency has undoubtedly caused

the operators of horticultural-specialty farms to know less about the advancement or progress among other farmers than is true for almost any other kind of crop, livestock, or livestock product farmers in the country.

Since the beginning of the twentieth century, most of the floricultural and ornamental horticultural crops have been produced by establishments which are so much larger than the average farm among all farms of the country as to be comparable only to a limited number of "large farms" or to "small manufacturers."

For older or more mature industries of agriculture, manufacturing, and commerce it is possible to trace the stages of early growth or development during which the problems of competition within the industry were considered as foremost to those of competition with other industries for the consumer's dollar. By 1950 the industry of floriculture and ornamental horticulture had only begun to recognize that its well-being is closely associated with the consumers' willingness and ability to spend an increasing share of their income for floricultural and ornamental horticultural products.

These are only a few of the reasons which have accounted for the virtual separation of horticultural specialty farming from other kinds of farming or business and in turn their exclusion from the thinking, planning, policies, and actions of agriculture, industry, and commerce in general.

State of the Industry

From an economic or business point of view commercial floriculture and commercial ornamental horticulture of the United States in 1950, may in general be considered as having developed or matured to the state which prevailed for other kinds of agriculture of the country in 1900. Hence, there is a real need for and a growing trade interest in the farm management and marketing phases of the industry.

During recent years progressive growers of the crops have begun to avail themselves of technological progress or scientific developments which are comparable to those which have been accepted by other farmers since early in the century. The benefits of hybridization, improved insecticides and fungicides and improved cultural and storage methods and manipulations have become generally recognized, though practiced by relatively few establishments. Very few growers have resorted to mechanization and such management practices of other farmers as cost accounting, work simplification, labor efficiency, space efficiency, and input-output relationships.

Marketing methods and practices have been even more static and antiquated than those for production of the crops. The pressure of in-

creased production as a result of technological progress is being felt in the market place. Much as agricultural economists may find a need for their knowledge and techniques among growers of the crops, there is by now an even greater necessity for the application of facts and enlightenment to the distribution problems of the industry.

Channels of trade have been experiencing some evolution. By 1950 many of the producers of floricultural and ornamental horticultural crops were wholesale growers. There has been a decided trend toward fewer and smaller retail growers. This trend was accompanied by marked increases in the percentages of retail business being conducted by establishments which were completely separated from production of the crops. Major exceptions to this tendency were businesses which developed both crop production and retail business in sufficient quantity to permit adequate management and accounting for each of the enterprises. A few large retailers found it necessary to remain in or enter upon crop production in order to provide certain kinds of commodities for their retail trade. Also, there are by now large growers who have entered upon the business of wholesale trade in order to sell their production more effectively and surely.

Among existing specialized retail and service trade channels of the industry recognition of competition with other commodities for the consumer's dollar has continued to be more vocal than real. It is not fully understood by the industry or those who look upon it, that the personalized and highly serviced kind of business continues to make up a major portion of the consumer spending with the industry. So called "legitimate retailers" of the industry have repeatedly wielded the threat of "black listing" or not buying from growers and wholesalers who would sell to other outlets, most particularly supermarkets, chains and similar kinds of businesses equipped to buy and sell large quantities at a relatively low markup. Especially to producers of the crops who are concerned about over production this situation is comparable to that for the food crops if the food which reached consumers was restricted to that amount which could be sold by so-called "fancy grocers" and that farmers, processors, and manufacturers were restrained from permitting much if any of the food to be sold through other markets.

For floriculture and ornamental horticulture, this problem is all the more pronounced when it is recognized that the only practical limitation to consumer spending for floricultural and ornamental horticultural products is the desire and the capacity to purchase.

Whereas most kinds of agricultural and industrial production have generally accepted and used grades and standards such criteria for many

horticultural specialty commodities, especially those of floriculture, are confined to given establishments or at best, local areas or markets.

There was a time when in this country many city dwellers purchased the milk, butter, eggs, or other farm produce of Farmer So and So. Much of the business of floriculture and ornamental horticulture of the United States in 1950 is still that personalized while major portions of the food and fiber requirements of consumers are purchased by grade, standard, or trade mark in huge, streamlined markets which bring together the products from farms, processors, and factories of many States and countries. The concepts of grades and standards, instead of personalized selling and services, are so new and so misunderstood by members of the industry of floriculture and ornamental horticulture that they are resisted or rejected by most operators.

Up to the present time no endeavor has been made to determine what size, grade or quality may be the most profitable or in greatest demand even though technological progress does by now permit the control and timing of growth and maturity. As would their predecessor in private estate or public park gardening, the plantsmen of the industry continue to strive for what they determine as cultural and varietal perfection and under commercial practices that aim results in production with gradations of size, quality, or utility.

Since the beginning of the century there has evolved for agricultural economists and others a most comprehensive series of information pertaining to prices and quantities of farm marketings as well as forecasts of most kinds of production. The horticultural specialties have been practically devoid of such data.

Market reporting is limited to a daily release by the New York State Department of Agriculture and Markets for New York City and an associated wire release as information for the gladiola growers in Florida and Alabama. To date there is no crop estimating for this segment of agriculture in the United States.

Conclusion

The acceptance and application of technological progress by the horticultural specialties is confined to recent years. As has been the experience of other kinds of agriculture and of industry since the initiation of the Industrial Revolution, technological progress among producers is soon accentuated by its impact upon the distributive system. This is where floriculture and ornamental horticulture now finds itself. Numerous and widespread as must be future improvements for production of the corps, sufficient progress has already been made to bring about the rec-

ognition of the need for its counterpart in research, improvement, and understanding of problems pertaining to the distribution and consumption of such goods and services. Here lies a challenge for agricultural economists and marketing specialists who may be interested.

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PROFIT MAXIMIZATION AND MEASURES OF FARM SUCCESS

FARM management investigators have employed a wide variety of measures of farm earnings or success. Each has apparently been developed to meet a certain need; however, their uses fall largely into two categories: (1) as extension devices for use in inter-farm comparisons and (2) as dependent variables in establishing relationships with certain characteristics of the farm business by cross-classification or by regression analysis. Thus, in their use it is implied that on the same farm an increase in the magnitude of the measure is, at least in some sense, desirable and might be attained by adoption of certain changes in the combination of inputs and outputs as suggested by the relationships revealed by the cross-classification or regression analysis.

The purpose of this note is to analyze general forms of measures and to specify conditions necessary for their maximization. Differences between these conditions and those necessary for profit maximization in the manner of Hicks[1] are noted. Finally a few remarks are made on the implications of aggregation.

To facilitate the discussion and analysis let us denote the physical quantities of outputs as $y_1, y_2, y_3, \ldots, y_n$ and the physical quantities of inputs as $x_1, x_2, x_3, \ldots, x_m$. Initially these are considered as rather broad classes of inputs and outputs. Thus the outputs would be such items as cash sales and products used in the household, while examples of input classes would be land, cash expenses, and labor. In order to isolate the effect of changing the combination of these broad classes on the various measures, it is necessary to make some assumption concerning the structure of subclasses of inputs and outputs within the aggregates. It is assumed initially that the "best" combination of subclasses within each of the input and output classes is employed. This means, for example, that the combination of livestock and crop sales within the class "cash receipts" is the "best" in the sense of making the measure considered as high as possible.

[1] J. R. Hicks, *Value and Capital*, Second Edition, Oxford, 1950, pages 319-320.

Residual Measures

Consider first the general type of measure which is computed by subtracting from gross income the cost, actual or estimated, of certain of the inputs. For example net farm income and labor income belong in this category.[2] This type of measure may be called a *residual* measure in contrast to *ratio* measures which are discussed below. We may define any measure of the residual type for a given accounting period as follows:

$$M = \sum_{i=1}^{n} p_i y_i - \sum_{r=1}^{k} c_r x_r \tag{1}$$

where p_i and c_r denote unit prices and unit costs of outputs and inputs respectively. It is to be noted that this is an accounting relationship. The unit prices and unit costs are assumed to be determined in a competitive market with the supply schedule of inputs and demand schedule of outputs being infinitely elastic. There exists also a technical relationship among the inputs and outputs:

$$F(y_1, y_2, y_3, \cdots, y_n, x_1, x_2, x_3, \cdots, x_m) = 0 \tag{2}$$

This relation, as well as (1), does not explicitly include the input to which any surplus will be imputed in the case of $k = m$. It is understood that there must exist some fixed resource to which this surplus may be imputed. This is usually treated as "management" by research workers; however, there may also be other inputs which are not susceptible of variation. These inputs are omitted from both (1) and (2) since by definition they cannot change in amount during the accounting period and hence cannot affect either the surplus or technical relationships. With respect to the problems of imputation and the necessity, for purposes of "exhausting the product," of assuming that (2) is homogeneous of the first degree in inputs, attention is invited to Samuelson's comment that such an assumption is not crucial.[3]

Since it is implicit that a higher value of a measure of success is to be preferred to a lower value, it is of interest to determine the quantities of outputs and inputs, y_i and x_r, that will yield a maximum value of M. These are found by maximization of (1) subject to the restraint of the technical production relation (2).[4]

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[2] See J. D. Black, *et al.*, *Farm Management*, Macmillan, New York, 1948, Chapter XXII for methods of computation.

[3] P. A. Samuelson, *Foundations of Economic Analysis*, Cambridge, Harvard University Press, 1948, pages 84-87.

[4] For a discussion of the procedure of maximization of a function subject to restraints, see R. G. D. Allen, *Mathematical Analysis for Economists*, Macmillan, London, 1947, pages 366-367.

In the case of $k = m$ we have the following familiar results as shown by Hicks[5] and others:

$$(3) \qquad -\frac{F_r}{F_i} \cdot p_i = c_r \qquad \begin{matrix} i = 1, 2, 3, \cdots, n \\ r = 1, 2, 3, \cdots, m \end{matrix}$$

where F_r denotes the partial derivative of F with respect to x_r and F_i denotes the partial derivative of F with respect to y_i. This relation (3) specifies that in order for M to be at a maximum the values of x_r must be chosen so that the marginal value productivity of each x_r in the production of each y_i—the left-hand side of (3)—is equal to the cost of x_r.

It should be noted that there are $n + m - 1$ independent equations of the type (3) and that these, together with (2), are sufficient to determine the values of the $n + m$ inputs and outputs. The second order (stability) conditions for M to be a true maximum are set forth in the reference cited and will not be repeated here. Suffice it to say that they insure a maximum instead of a minimum or instability. In the ensuing discussion it is assumed that the stability conditions are satisfied in the evaluation of each measure.

Let us return to the analysis of (1) and consider the case of $k = m - 1$. This is frequently used by farm management workers to show, for example, returns to "labor and management" or returns to "capital and management." Using the procedure outlined above, the maximization of (1) subject to (2) results in the same required conditions as in (3) for all marginal rates of transformation with the exception of those involving x_m which appear as follows:

$$(4) \qquad -\frac{F_m}{F_i} \cdot p_i = 0 \qquad i = 1, 2, 3, \cdots, n$$

This means that in order to maximize M when $k = m - 1$, x_m would be added until its marginal value productivity in terms of each output y_i is equal to zero. This is due to the fact that the omission of x_m in (1) is equivalent to saying that it has no cost. In the more general case where $k < m$, M would be maximized when the last $m - k$ inputs attain values which make their marginal value productivities in the production of each output, y_i, equal to zero. Finally where $k = 0$ and still under the assumption of selling outputs in a competitive market, maximization of M would be equivalent to maximizing total physical product. It can be seen that for all instances where $k < m$, the requirements for a maximum of M deviate from those specified in (3) in the direction of demanding a higher level of input of the last $m - k$ inputs than necessary for maximization of returns to the fixed resources.

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[5] J. R. Hicks, *op. cit.*

Ratio Measures

Ratio measures constitute the second general type of measures of success. The numerator of the ratio is usually one of the residual measures and the denominator contains certain selected inputs. Ratio measures purport to measure "efficiency" in some sense of the inputs placed in the denominator. Frequently ratio measures consider the "efficiency" of a single input, and in these instances this input is measured in physical terms. Thus we have:

$$(5) \qquad R_1 = \frac{\sum_{i=1}^{n} p_i y_i - \sum_{r=1}^{k} c_r x_r}{x_t} \qquad \begin{array}{l} i = 1, 2, 3, \cdots, n \\ r = 1, 2, 3, \cdots, t-1, t, t+1, \cdots, m \\ 0 \leqq k \leqq m \end{array}$$

If $k = m$ and x_t is the number of acres, the measure R_1 would define returns to the fixed resources per acre; if $k = m - 1$ and x_t is months of labor, R_1 would define returns, including returns to any fixed resources, to the m th input as a residual on a per man month basis. It should be noted that, in a sense, (1) is a ratio measure; the fixed resource may be considered as a single unit making the denominator one.

Again since it is apparently desirable to have high "efficiency" in the use of x_t, let us maximize R_1 subject to the production relation (2). In the special case of $k = m$, this process yields the same conditions as previously outlined in equation (3) with the exception of the relation involving the input x_t, which is as follows:

$$(6) \qquad -\frac{F_t}{F_i} p_i = c_t + R_1 \qquad k = m$$

This relation specifies that in order to maximize (5) the level of x_t must be such that its marginal value productivity is equal to its marginal cost plus R_1. Under the assumption of diminishing marginal productivity this would be expected to result in a smaller input of x_t than under the profit maximization conditions (3).

Another variation of the ratio measure is that in which the "efficiency" of a group of inputs is considered. One common characteristic of such inputs is that they are not completely transformed into products during the accounting period. Rate earned on investment is of this type.[6] Calculation of the numerator for this type of ratio measure provides for a deduction of costs of all inputs except those appearing in the denominator. Assuming that the physical units, x_r, of the last m-k inputs are measured in monetary terms to permit summation, we may write:

$$(7) \qquad R_2 = \frac{\sum_{i=1}^{n} p_i y_i - \sum_{r=1}^{k} c_r x_r}{\sum_{r=k+1}^{m} x_r} \qquad 0 \leqq k < m$$

[6] See J. D. Black, *et al.*, *op. cit.*

Maximizing (7) subject to the restraint of the technical relation (2), we have for the first k inputs the same necessary conditions as for profit maximization (3). However the optimum quantities of the last m-k inputs are determined by the following relations:

$$(8) \qquad -\frac{F_s}{F_i}\cdot p_i = R_2 \qquad s = k+1, k+2, \cdots, m$$

Thus in order to maximize R_2 the marginal value productivity of each of the last $m - k$ inputs must be equal to R_2 itself. There is no reason to believe that the value of R_2 will coincide with the marginal cost of each of the last $m - k$ inputs as required by (3) for profit maximization. If $k = m - 1$ and there is no surplus accruing to the fixed resources, the level of x_m required by (8) would be that at which average returns to x_m are maximized. Thus under the assumption of diminishing marginal productivity, an insufficient amount of x_m would be used to maximize profits; however, the "efficiency" of x_m would be higher than if profits were maximized.

Another variety of the ratio measure may be represented as follows:

$$(9) \qquad R_3 = \frac{\sum_{i=1}^{n} p_i y_i - \sum_{r=1}^{k} c_r x_r}{\sum_{r=1}^{m} c_r x_r} \qquad \begin{matrix} i = 1, 2, 3, \cdots, n \\ r = 1, 2, 3, \cdots, k-1, k, k+1, \cdots, m \end{matrix}$$

In the special case of $k = m$, this measure is termed "net management ratio" by some workers.[7] The conditions necessary for the maximization of R_3 in this case are as follows:

$$(10) \qquad -\frac{F_r}{F_i}\cdot p_i = c_r \cdot \frac{\sum_{i=1}^{n} p_i y_i}{\sum_{r=1}^{m} c_r x_r}$$

Instead of adding inputs, x_r, to the point of the equation of marginal value product with the cost of the input, c_r, as required by (3), (10) requires that x_r be added until its marginal value product is equal to its cost per unit multiplied by the ratio of total returns to total costs. Only in the case of no surplus or no loss to fixed resources (numerator of $R_3 = 0$) would the results be identical with (3). If a surplus were present (numerator of $R_3 > 0$), the amount of each input would be less than (3); if a loss occurs (numerator of $R_3 < 0$), then the amount of inputs required would be greater than (3).

Another variation of (9) is referred to by some workers as "gross ratio"; it provides for no deduction of costs in the numerator ($k = 0$).[8] The condi-

[7] H. C. M. Case and P. E. Johnston, *Principles of Farm Management*, Lippincott, 1953, Chapter 15.

[8] H. C. M. Case and P. E. Johnston, *ibid.*

tions necessary for a maximum in this case are identical with those of (10), the measure commonly called the "net management ratio." This is not surprising since if the same methods of computation are used, the values of these measures should differ by unity.

Implications of Aggregation

In conclusion it is well to consider briefly some of the implications of the assumption that the "best" combination of outputs and inputs within each class is employed. Relaxation of this assumption indicates that the magnitude of any measure is affected by the degree of deviation from the necessary conditions among aggregates for maximization (relations (3), (4), (6), (8), and (10) above), as well as the deviation from a set of maximum conditions applicable to the more refined inputs and outputs within aggregates. It would seem that meaningful interpretation of the effect on measures of success of the latter (sometimes called "practices" or "efficiency factors") must presume among other things that relatively little or no variation in the measure stems from variation in the proportion in which aggregates are used.

The ideal solution, of course, lies in the determination of the technical relation (2), not for aggregates, but for units that have operational meaning to farmers. It should be recognized that studies of factors affecting farm earnings, in a sense, attempt to do just that. But, in general, the aggregation employed in the independent variables themselves, among other things, prevents direct utilization of the results by farmers. This suggests that it may be more efficient to attempt to synthesize the technical relation (2) by building from intensive study of the technical relations of each enterprise. This would likely mean a greater emphasis on the use of such sources of data as controlled experiments, time and motion studies, and the detailed cost type of farm record.

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* Reviewed in this issue.

BOOK REVIEWS

Farm Management Analysis, Lawrence A. Bradford and Glenn L. Johnson, John Wiley and Sons, 1952, Pp. xi-437. $5.75.

The authors begin by pointing out that "Management is an intangible part of production which develops within the lives of men. It is first a mental process, a concentration of desires, a will power." *Management* is defined, in effect, as what a *manager* does. The management function is outlined as being that of "observation, analysis, decision making, action, and acceptance of responsibility."

Management is made necessary by the uncertainties of imperfect knowledge in a dynamic economy—imperfect knowledge of present and future production technology and prices, and of personality and institutional forces that affect the farm business. "Knowledge of the situation may range all the way from knowing nothing about the future event or process to knowing everything about that event or process," and is classified by the authors (following more recent theorists) as (1) Inactive situation, (2) the learning situation, (3) the forced action situation, (4) the subjective risk situation, (5) the subjective certainty situation.

"This book is predicated on the conviction that managerial capacity can be taught and/or developed. . . . Management principles . . . deal with the process of economizing in the performance of the five managerial tasks. It *costs to perform* these tasks, and their performance has value . . . *the core of the managerial principles is the equating of additional costs and additional returns as a condition defining an optimum position.*" The principles of increasing efficiency of management are the principles of learning (both deductive and inductive), and the principles of strategy (personal and impersonal). The above concepts are elaborated upon in the first three chapters comprising Part 1—orientation.

In their foreword the authors point out that the book is a blending of the "old" and the "new." In the first chapters of Part 2 the reader gets the feeling that the "mixture" was really a "suspension" and the two separate bodies of concepts and tools have "precipitated." Traditional farm accounting concepts are explained with the usual imputed returns and efficiency factors being calculated. Their general approach to farm organization is to classify assets with respect to fixity and begin with the most fixed (usually land) and work on through. At this point (Ch. 8-12) the student is made familiar with the fundamental principles of the economics of production (the "new"). These concepts are quite soundly integrated into the role of making maximizing decisions. Errors of formula notation on pages 131 and 160 will not add to the comfort of agricultural students whose mathematical maturity ended with long division. Occasionally,

terminology lacks precision, and a few graphic illustrations will not be sufficient for some who hold that illustrations must be conceptually and mathematically defined.

A chapter on cost of production concepts is included, being "predicated on the assumption that 'good' cost figures and concepts are highly useful." The chapter states, also, "Confusion as to whether an input is fixed or variable, results in dangerous inconsistencies which make it virtually impossible to make cost computations." One is not told specifically how total costs or average costs are used by the farmer in performing his managerial function.

The reviewer was particularly disappointed when, after finally learning of the "maximizing" principles of production, he came to the *crop* program to find so many solutions made by traditional *rule of thumb*. The fertilizer problem is solved by such recommendations as "Two tons of ground limestone for humid areas once about each 10 years" and "Addition of 20 pounds of P_2O_5 per acre per year to maintain phosphorus on soils of a productivity of 50 bu. of corn or more per acre." This procedure is neither necessary for or consistent with the more precise concepts so elequently pleaded. A commendable and, in the main, very satisfying section is found under the heading of "Input-Output Relationships" for hog, dairy and beef production. It is unfortunate that the results of recent physical experiments and logical functional relationships were not incorporated into the problems of organizing the crop program. Lack of regional homogeneity is more restrictive to the application of these tools to the crop program than to the livestock program, but it is undoubtedly even more restrictive to the application of the "rule of thumb" solution.

The authors conclude Part 2 with a rather thorough discussion of prices and the use of the general budget. Many farm management teachers will feel that not enough emphasis has been placed on *partial* budgeting techniques. It is the opinion of this reviewer that section 2 could have been shorter and more useful had it followed the discussion of economizing principles directly with the chapter on budgets and then had applied *both* to the solution of more of the problems that arose.

In Part 3 the authors review the function, objectives and principles of management with regards to the *operation* of the farm business in a dynamic economy. This section may not be readily comprehended or appreciated by the undergraduate agricultural student, but it will undoubtedly provide initial impact for reflection on the part of the professor as well as the serious student of agricultural economics.

A dictionary definition of *analysis* includes "A break-down of anything into constituent elements to distinguish its component parts separately or in relation to the whole." Traditional farm management has been far more

concerned with the analysis than it has been with the *synthesis*—the combining of the relevant component parts into a whole. In this sense, this book exceeds the specifications of its title.

The goal of integrating the different schools of farm management both in concept and in tools and method is a worthy one. In the opinion of this reviewer, the task has not been completed in the writing of this book, although it goes farther than anything previously available in bringing the issues together so that delineation can be made between those on which compromise can and cannot be obtained.

JOHN A. HOPKIN

University of Wyoming

Farm Policies of the United States, 1790-1950: A Study of Their Origins and Development, Murray R. Benedict, New York: Twentieth Century Fund, 1953. pp. 548. $5.00.

This is indeed a valuable contribution to agricultural economics literature. Professor Benedict has given us more than a history of farm policies of the United States. He has given us an economic history of the United States with special reference to governmental policies relating to agriculture.

After an opening chapter dealing with the formation of American land policy beginning in 1785, the next three chapters deal with early monetary developments, tariff policies and the development of roads, canals and highways.

Economists have often expressed the desire for an economic history written and interpreted by an economist. Professor Benedict not only has recorded the facts in great detail, he has interpreted them in the light of his economic training and experience.

The outstanding contribution of this book, however, is the wealth of detail which has been organized and woven into the treatment of the policy developments over the 160-year period. In other words, *Farm Policies of the United States, 1790-1950* is more in the nature of a source book, standard reference and commentary on 160 years of farm policies rather than a broad interpretation of them based on integrating hypotheses.

Students interested in the historical aspects of agricultural policies will find detailed references to the relevant literature beginning with the colonial period. Roughly one-half of the book, 231 pages, are devoted to the period since 1930.

In spite of the large number of programs in this recent period, Professor Benedict has found it possible to include at least a brief account, a

critical appraisal and a citation to some of the source materials covering each of these developments.

Students interested in an exhaustive account of these more recent policy developments will want to consult the numerous source materials available. But the student or other reader who wants only a brief summary and evaluation of the many policy developments in this period will find just what they need in this book.

One cannot review the development of farm policies in the United States over the 160-year period without gaining new perspective regarding existing policy problems.

WALTER W. WILCOX

Library of Congress

Time and Motion on the Farm, Brian Branston, London: Faber and Faber, Ltd., 1953. Pp. 123. 15 shillings.

The author of this book, a specialist in farm radio broadcasts, apparently has a deep concern with the low production per worker in British agriculture. He indicates in the beginning that in spite of mechanization and large investment in equipment, production per man has actually declined 7% since pre-war. He feels that in the long run British agriculture must make more efficient use of its man power resources in order to effectively maintain its position and meet the competition from other areas.

Thus the book is directed to the British farmer and the approach is made in a popular non-technical manner with snatches of Yorkshire wit thrown in here and there. The 119 pages are divided into two parts–Theory and Practice.

In Part one, the author builds up an understanding of the need for the individual farmer to obtain some check on his production methods, especially chore practices. This leads into a discourse of basic psychological aspects of labor and output including such items as satisfaction, habit, incentives, and fatigue. The next chapter is a clear description, well illustrated with charts, of the essential steps in time and motion studies. The technical phases are well handled and easy to follow.

A good illustration of the author's tactful approach in convincing British farmers to do something about their production problems and seek some outside help on their individual farms in beginning the process of finding better practices follows.

". . . Habit works against the farmer too in another way: it prevents him from seeing the wood for the trees. By this I mean that a farmer works close up to his job day in and day out until he finds it impossible to see whether his habits are bad or good. This point is well brought out by a story told by Ted Drake, on whose farm I did the T & M study already referred to, and which I shall explain in some detail later on. 'I remember one day last sum-

me,' said Drake, 'when I went across to one of my neighbour's cowhouses and I saw the cows had been rubbin,' "You've got lice," I said. "No, I don't think I have," he said. "But look how they're rubbin'," I said. Oh, his cows had lice all right and he hadn't noticed 'em rubbin' because he saw 'em every day. But to cap this—hang me if I didn't see my own cows rubbin' when I got back.' And they'd been doin' it a long time. That's what I mean when I say we work too close to our jobs to notice where we can make improvements."

In Part 2, the practical application of time and motion studies are shown by a few examples on Ted Drake's farm. These examples of course are pointed toward stimulating British farmers and while the conditions and practices are not the same as ours, I believe that farm leaders and Extension personnel anywhere can gain an understanding of the possibilities of time and motion studies in improving farm practices.

In this reviewer's judgment, time and motion studies represent only one part in the task of improving the output of labor and the net income of the individual farm. That is, a new and improved way of doing a certain operation must usually be accompanied by a reorganization of the farm as a producing unit before benefits of the improved practice are fully exploited. Thus some small improvement in one operation may mean the freeing of labor for other production.

The imagination and skill of the operator in readjusting his resources as applied to the entire farm as an operating unit is a very important part in the development of an efficiently operated farm. Mr. Branston indicates an awareness of this point but he might well have given it more emphasis.

In fact, the decline of output per man in British agriculture, in spite of mechanization and high investment in new equipment might well be a situation in which the farmer has saved time on certain field operations but has not yet been able or seen the need for the reorganization of the entire farm as a producing unit. Borrowing from experiences in New England, the reviewer can recall instances in the past where the purchase of a tractor and other machines by an individual farmer did not increase total output per man and actually raised the total cost of operation. But soon some of these operators found that by reorganizing their entire production process, they could not only increase total output per man but could raise substantially the net income of the farm. On the other hand, I am sure we could find some farmers who bought tractors and a host of other equipment in the last ten years but due to lack of imagination and vision have failed to make the other essential changes and in consequence are now worse off than before.

Thus this reviewer would add a plea to use time and motion studies mostly as one part or one step in a larger, broader program of farm planning: Planning the farm as a producing unit.

Mr. Branston has made a contribution to agriculture by writing a very readable, brief description of the possibilities of time and motion studies for British farmers.

HARRY C. WOODWORTH

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The Land System in Palestine, History and Structure, A. Granott, London: Eyre and Spottiswoode (British Book Centre, 122 E. 55th Street, New York) 1952. Pp. xi, 359. $4.50.

This book will be of particular value to those agricultural economists interested in land tenure, land reform and historical changes in land systems. The scope of the study is broader than the title indicates since the author has included besides Palestine those adjoining countries that have a similar historical, social, and economic development.

Two chapters of particular interest include the first, which gives an historical sketch of the landed property from early times, and the last which presents a good description of the tenancy situation that has prevailed in the past. The development in the twentieth century of the leasehold system in the Jewish rural economy is particularly well presented. The remaining chapters mainly are devoted to a break-down of the distribution of landed property by individuals, institutions, and size of holdings.

A great amount of material is presented, but at times in the middle chapters the statistical data are excessive. The inclusion of fewer facts in these chapters would make the book more readable, especially for those not familiar with the subject treated. Foreign names and terms are used frequently throughout the book, many times with little explanation of their meaning. A glossary is not provided but would have been a tremendous aid in making the book more understandable.

No attempt was made by the author to analyze the changes in agrarian structure that have been brought about by the formation of Israel. From this standpoint he fails to complete the picture on the history and structure of the land system in Palestine, but he explains this omission by saying, "It is still impossible to draw conclusions and to survey new developments with anything approaching the objectivity of the scholar."

The author, Dr. Granott, settled in Palestine in 1922 and is looked upon as an expert on land economic and fiscal problems of that area.

E. HOWARD MOORE

University of Maine

Research in the Economics of Forestry, William A. Duerr and Henry J. Vaux, Editors, Washington, D.C.: The Charles Lathrop Pack Forestry Foundation, 1952. Pp. xi-475. $6.00.

Agricultural economists will have little difficulty in sensing the im-

portance of a volume which parallels, in the field of forest economics, the earlier Social Science Research Council series of bulletins on scope and method in agricultural economic research. More than 80 contributors, advisers, and associates have assisted the editors in presenting authoritative discussions on 127 research problem topics. The result will provide much stimulating thought for forest economists and agricultural economists alike.

The individual research topics have been fitted into six chapters which deal successively with the forest economy at large, the agents of production, the management of forests, harvesting and processing operations, the meeting of supply and demand for forest products, and the nature of demand for forest goods and services. Preceding these chapters is an introductory one which provides a general background to forest economics research and a discussion of methodology. The final chapter deals with the coverage and organization of forest economics research in progress in the United States between 1940 and 1950.

The stated objectives of the book include defining the economics of forestry as a field of organized knowledge, and exploring the methods of the field. The illustrative topics obviously serve the latter objective, and are also intended to serve the former one by specifying the subjects contained in the field, by showing their interrelationships, and by emphasizing their essential unity. The editors view the topic statements as construction timbers, and state that they have attempted to erect these timbers into the framework of a house, instead of merely heaping them up or sorting them into stacks of similar size or grade.

The editors' concern with fitting the timbers together into a complete structure has been so great, indeed, that many of their topics turn out to be rather unwieldy prefabricated sections in which some of the supporting timbers are concealed. Few of the topics have been restricted enough in scope to compare with an ordinary research project. Too often, the contributors have been faced with broad topics including varied problems, and have been able to do no more than generalize with respect to procedures. Thus the individual statements tend to be general discussions of the problems likely to be encountered in broad areas of research, rather than detailed outlines of procedures to be followed in specific illustrative projects—real or hypothetical. This is a departure from the form of the bulletins on scope and method in agricultural economics, and it involves a definite sacrifice of readability.

Both of the editors have training and experience in forestry and in economics, and many of their collaborators are similarly qualified. Readers are not likely to be disappointed in the quality of their work. Contributors have given the marginal analysis a thorough work-out under static conditions, but have paid much less attention to the problems of decision-mak-

ing in a dynamic environment—problems of no small importance for an industry whose production period is measured in decades.

Disagreements over methodology are notably inconspicuous. Perhaps this is because such disagreements have not had much time to develop in this relatively new field of research or perhaps it is another indication of the editors' preoccupation with fitting their timbers together to form a complete house. Discussions of alternative methods and viewpoints account for little if any of the overlapping among topics, but considerable overlapping arises because each timber must be viewed in its relationship to many other parts of the proposed structure. The extensive cross-referencing is designed to avoid some duplication, but the calculated policy has been to compromise between the needs of the reference user and the sustained reader.

Altogether, the compromise is not a happy one for the sustained reader, and it leaves something to be desired by the reference user, who would, no doubt, be pleased to find more emphasis on alternative approaches to more specific problems. The book will have its greatest appeal, in this reviewer's opinion, for a third type of reader, the browser, who will be able to return to the book time after time and find stimulating ideas by turning to almost any of the topical discussions or supplementary sections.

R. G. WHEELER

Harvard University

Valley of Tomorrow—The TVA and Agriculture, Norman I. Wengert, Knoxville, Tenn.: Bureau of Public Administration, Univ. of Tenn., Record Extension Series, Vol. XXVIII, No. 1, July 1952. Pp. xv, 151.

President Eisenhower's remarks on the TVA (in relation to "creeping socialism")[1] have revived animated discussions on that subject after what seemed almost like a lull in public interest in the program. It is most fortunate that at this particular moment Professor Wengert's book is available to us. The author's actual association with the TVA and his determination—and his successful attempt—to review the problems objectively make his book most valuable.

In his opinion, TVA is a "significant contribution to the theory and practice of modern government" and an "inspiring vision of human im-

[1] Referring primarily to the electric power problem, the President stated that "he is not out to destroy TVA. It is one experiment. He also said that in other areas when we repeat that thing [the TVA experiment] he wants local people to have a greater interest and a greater voice in it." The *N.Y. Times* summarized by saying that the President "asserted in explaining what he meant by creeping socialism, that he had said the TVA was attracting industry through cheap power rates from other regions." Reported by the *N.Y. Times*, 6-8-53, p. 18, col. 4, as an unofficial transcript of the President's news conference with the President's remarks in indirect discourse as required by White House rules.

provement through deliberate rational action in a great natural region—all in the framework of democratic concepts and beliefs." But the author goes way beyond repeating often heard *clichés*. His study has three objectives: the recording of factors influencing the origin and development of the TVA agricultural program; the description of the content and direction of that program; and the evaluation of the difficulties (conceptional and practical) that arise out of a regional approach to resource development. In particular, he analyses the personal, institutional, cultural and natural forces which shaped the success or the failure of the various phases of the program.

The agricultural phase of the TVA is used as "a case study on the basis of which generalizations applicable to the regional agency approach can be made. Wengert examines in turn the fertilizer problem, the test demonstration farm, local organization and administration, regional coordination, administrative relations—dealing primarily with the TVA's relation with colleges, the USDA and SCS—the impact of the project on national agriculture. The final chapter is an overall appraisal of the performance of the authority. One of the most lucid readings is in Chapter I which outlines the development of regionalism, and the concepts of planning, integration and decentralization in connection with the TVA.

With regard to the fertilizer question, Wengert points to the importance which the fertilizer phase has attained in the agricultural program. ("Without phosphate the present agricultural program would collapse"—p. 136.) He believes that the emphasis on phosphate distinguishes TVA from the normal agricultural extension program and notices that problems such as the need for capital, or tenure have not been given due attention. Regional cooperation has been realized only partly. Since "region," "regional problems," "regional solutions" are concepts which have become so familiar in our thinking and actions, his analysis of the reasons for the failure to create a unified program is of great value to all agriculturists. However ". . . the failure to develop fully effective intergovernmental relations in agriculture cannot be charged wholly to TVA, but is to a large extent inherent in the situation in which national policy remains chaotic" (p. 139).

Throughout the book, Wengert points at the basic difficulty which besets many of our programs: i.e. the absence of clear-cut, well defined rights and obligations of the people or agencies involved in carrying them out. Of course, laws and regulations will not eliminate the difficulties and conflicts of personal, political or subject matter, but they will help by setting up methods and procedures to deal with them.

ERNEST FEDER

South Dakota State College

The Decline of Agrarian Democracy, Grant McConnell. Berkeley and Los Angeles: University of California Press, 1953. Pp. 219, $3.75.

Grant McConnell's *Decline of Agrarian Democracy* adds to the slowly growing body of information on the political science of agriculture. It is a case study of the interplay of institutional forces in the development of public agricultural policy. It is an analysis of the bargaining position and strength of the USDA, the political party, Congress, and the pressure group.

Because the drives, desires, compulsions, reactions and interactions of these institutions are intangibles which cannot be neatly measured, charted, and predicted, it is difficult to determine whether the author has assigned proper weight to the various factors involved in the struggle for political power over the agricultural sector of government. Nevertheless, because the bargaining process in the political arena may have a great effect upon the welfare of the farming population, it is desirable that more and more of such institutional case studies be undertaken.

As the title of his book reveals, Mr. McConnell's thesis is that the ascendancy of the Farm Bureau in agrarian politics represents a sharp break with the great agrarian democratic movements of the 19th century. Whereas the earlier groups arose in protest against new systems of power which were developing out of the "raw and turbulent capitalism of the era," the dominant farmer pressure group of the mid-20th century is itself a new power structure which, rather than having the traditional agrarian distrust for power, seeks to extend its power over every level of government. Although the *Decline of Agrarian Democracy* is centered around the Farm Bureau's attack upon and destruction of the Farm Security Administration, it tells a story of the Farm Bureau's drive to control agricultural policy since the early 1930's.

Mr. McConnell does not picture the Farm Bureau's campaign against the FSA as a class attack of large commercial farmers against low income subsistence farmers and tenants. He points out that certain organizations representing large farming interests bent on retaining a cheap labor supply supported the Farm Bureau in its attack on the FSA, and he indicates the unrepresentative nature of Farm Bureau membership; but he does not see class conflict as the chief reason for the Farm Bureau's animosity toward the FSA. Rather, he views the destruction of the FSA as a part of a pressure group's drive for power over public agricultural activities. It was, in McConnell's analysis, a part of a larger campaign which included the elimination of all competitors or potential rivals for farmers' loyalties and allegiance. Thus, the Farm Bureau aided in blocking the formation of a national organization of PMA committeemen, and it destroyed the Land Use Planning Committees of the Bureau of Agricultural Economics. In

recent years, it has, according to the author, seen its most serious rival in the Soil Conservation District supervisors' movement. Thus, it has sought to eliminate the Soil Conservation Service as a distinct entity.

Not only did the Farm Bureau, in the author's judgment, seek to destroy or control those agencies within the USDA which, through their local farmer committee systems, might rise to challenge Farm Bureau power, but it sought the elimination of the executive branch and the political party from the formulation of agricultural policy. Although the Farm Bureau until 1940 had apparently been willing to share responsibility for the development of the new farm programs with the Democratic Party, after that time the formulation of policy became a disputed function. "No longer was the Farm Bureau willing that the administration should share in it."

The violent opposition of the Farm Bureau to the Brannan Plan, in McConnell's view, was due not so much to the content of the plan as to the fact that the plan represented an effort of the administration and the party to reassert its leadership in policy formulation. Although the whole system of price supports had evolved under the aegis of the Democratic Party, the Brannan Plan was denounced as an assualt on "bipartisan" farm policy. According to the author, bipartisanship places policy development outside the control of either party. Thus, a bipartisan policy would in reality be a Farm Bureau controlled policy.

The importance of administration in the struggle for governmental power is spelled out by McConnell. Weaknesses in administrative organization and in the administration of programs have been the camouflage for hiding the real purpose of Farm Bureau attacks, which was to gain control over the administrative structure. From 1940 until the appearance of the Brannan Plan, Farm Bureau attacks upon the administration were concentrated on organization and administrative machinery. Although it was possible to reach compromises on the character of agricultural programs, no agreement could be reached on the distribution of functions among the various agencies. The Farm Bureau's solution to the "duplication and overlapping" of administrative activities which it found so horrifying was to turn the new federal programs over to the states for administration. Rightly or wrongly, it believed that it could dominate Extension administration of such programs.

The foregoing summary is sufficient to indicate that the author has a thesis—namely, that agrarian democracy has degenerated into a power complex—and he presents his argument well, and with careful documentation. Some readers may not agree that the transformation has actually been as radical as portrayed, or they may feel that, in his effort to build his thesis, he has minimized certain factors in the political milieu, and has

developed an oversimplified theme of a pressure organization's drive for power. At any rate, students of agricultural policy will find this well written book extremely provocative.

W. ROBERT PARKS

Iowa State College

Law and the Farmer, Jacob H. Beuscher, New York: Springer Publishing Company, Inc., 1953. Pp. 406, $4.95.

The author is a Professor in the Law School at the University of Wisconsin. He also teaches a course in Farm Law for students in the College of Agriculture. This book is designed for "ag. students," so the approach and language used is much different than commonly found in texts prepared for students in law schools.

The book is written in a language that can be understood by persons not trained in law, yet it is sufficiently precise to hit the nail on the head when it comes to handling some of the common everyday legal problems confronting farmers. While it is intended for class room purposes it has a much wider application in the field of agriculture, especially for farmers and others who try to maintain a usable practical library.

At the very beginning the author states that the role of law in our society is to prevent disputes as well as settle them. All through the book the preventative side of the law is kept in the forefront.

In the introductory chapters attention is given to: the role of law in our society; the way law is made; how cases get into court and how they are tried; differences between civil and criminal law; substantive and procedural law; public and private law. This is excellent background information for anyone not familiar with the way the legal system works.

Attention is then given to the many legal problems and pitfalls to avoid in leasing a farm as well as in buying and selling a farm. But it is in the later chapters which deal with methods of transferring farm property, federal estate taxes, state inheritance taxes, federal income taxes, costs of settling estates, etc., that the author makes his real contribution as far as agricultural economists are concerned. Extension specialists and college professors that operate in this area will find these chapters particularly informative.

As a matter of fact the discussion on joint tenancy, inheritance laws, wills, probate procedure, gift and death taxes etc., is presented in a more understandable fashion than one usually finds in either the statutes or legal text books.

In the latter chapters of the book the author deals with the farmer as a creditor; the farmer as a debtor; fence laws; water rights, and trespass laws.

J. B. KOHLMEYER

Purdue University

JOINT SESSIONS
AMERICAN FARM ECONOMIC ASSOCIATION
AND
OTHER PROFESSIONAL ASSOCIATIONS
DECEMBER 28-30, 1953
WASHINGTON, D.C.

Monday Morning, December 28—With Econometric Society

APPLICATIONS OF ECONOMETRICS TO AGRICULTURE

Chairman: Karl Fox, Bureau of Agricultural Economics
Papers: Commodity Futures, H. S. Houthakker and L. G. Telser, Cowles Commission
A Model to Explain the Short-term Demand for Apples, L. L. Boger, Michigan State College
Productivity Estimates from Experimental Data, Clifford Hildreth, University of North Carolina
Discussion: Holbrook Working, Food Research Institute
A. H. Harrington, State College of Washington
George M. Kuznets, University of California

Tuesday Morning, December 29—With American Economic Association

FARM PRICES AND FARM INCOMES IN AMERICAN AGRICULTURE; IS AMERICAN AGRICULTURE STILL ESSENTIALLY COMPETITIVE AND LAISSEZ-FAIRE?

Papers: The impact of government programs on farm incomes
M. R. Benedict, University of California
Competition in agriculture: fact or fiction
Gale Johnson, University of Chicago
Discussion: O. V. Wells, Bureau of Agricultural Economics
Glenn Johnson, Michigan State College
H. B. James, North Carolina State College

Tuesday Evening, December 29—Dinner for Agricultural Economists

IMPORTANT PROFESSIONAL PROBLEMS FACING THE AGRICULTURAL ECONOMIST

Chairman: Bushrod W. Allin, Bureau of Agricultural Economics
Discussion: J. D. Black, Harvard University
T. W. Schultz, University of Chicago
Group Participation

Wednesday Morning, December 30—With American Statistical Association

DEMAND ANALYSIS BASED UPON CONSUMER-PANEL DATA

Chairman: Frederick V. Waugh, Bureau of Agricultural Economics
Papers: The demand for citrus products, G. M. Kuznets, University of California, and R. J. Foote, Bureau of Agricultural Economics
The demand for meats, Ayers Brinser, Harvard University
Demand analysis from the M.S.C. consumer panel, G. G. Quackenbush, Michigan State College
Discussion: Marguerite Burk, Bureau of Agricultural Economics
Margaret Reid, University of Chicago

NEWS NOTES

AWARDS FOR 1954

The American Farm Economic Association will make the following awards in 1954: (1) Award for the best article published in the *Journal of Farm Economics* in 1953, (2) Awards for published reports of research in the field of Agricultural Economics, and (3) Awards for theses submitted in partial fulfillment of requirements for the degree of Doctor of Philosophy in departments administering majors in Agricultural Economics.

Award for Best Journal Article

For the article judged best among those published in the *Journal of Farm Economics* during the calendar year 1953 an award of $100 will be made. The selection will be made by the Editorial Council.

Awards for Published Reports of Research in Agricultural Economics

1. For the year 1954, there will be three awards of $250 each. Each award will be in a different field of Agricultural Economics.
2. Publications including books, bulletins, articles, and pamphlets submitted for consideration will be classified in the following fields, and persons submitting items should indicate the field in which they believe the reports should be classified.
   (a) Farm management and production economics
   (b) Agricultural marketing
   (c) Agricultural prices
   (d) Agricultural finance
   (e) Land economics
   (f) Theory and methodology
   (g) Agricultural policy
3. Selections will be made from published research bearing the publication date of 1953.
4. Only publications prepared by persons 40 years of age or less at the time of publication will be considered.
5. A report of research published in the *Journal of Farm Economics* by a person 40 years of age or less at time of publication may be entered and considered for an award for published research. It will also receive consideration for the best *Journal* article, but may receive only one award.
6. The Awards Committee for Published Reports will be made up of seven persons, in addition to the Chairman, representing the various fields which have been designated.
7. Publications must be in the hands of the Chairman of the Committee, H. Brooks James, Department of Agricultural Economics, North Carolina State College, Raleigh, North Carolina, on or before *March 1, 1954*. Eight copies of each publication entered are requested, but fewer copies will be accepted in such cases as articles appearing in national journals or books otherwise available to the judges. In no event should less than three copies be sent.
8. Members of the Awards Committee for Published Reports will not be eligible to submit papers of their own.
9. Announcement of the awards will be made on or before the time of the 1954 annual meeting of the American Farm Economic Association.

Awards for Ph.D. Theses

1. For the year 1954 there will be three awards of $250 each for Ph.D. theses.
2. Theses in any field of Agricultural Economics may be submitted. Theses prepared by candidates for the Ph.D. degree in any department of Economics or Agricultural Economics in the United States are eligible for consideration, when submitted by the head of the department in which the work was done. No department, however, may submit more than one thesis.
3. Selections will be made from theses submitted to a graduate school faculty during the calendar year 1953.
4. A published Ph.D. thesis may be entered in both the published report and the Ph.D. thesis classes but shall be eligible for only one award.
5. Theses must be in the hands of the Chairman of the Committee, H. Brooks James, Department of Agricultural Economics, North Carolina State College, Raleigh, North Carolina, on or before *March 1, 1954.*
6. The Theses Awards Committee will be made up of three persons in addition to the Chairman.
7. Announcement of the awards will be made on or before the time of the 1954 annual meeting of the American Farm Economic Association.

T. K. COWDEN, *President*

NOTE: The Awards Committee solicits the cooperation of members of the Association in encouraging participation in the program. Recognizing the reluctance of some authors to enter their own published reports, members may encourage them to do so, or arrange for others to submit published reports on behalf of eligible authors. Announcements of the Awards Program suitable for posting are available upon request to the chairman of the Committee.

See back cover page of Proceedings issue of the Journal for the announcement of the recipients of the 1953 awards.

The following have been appointed chairmen of various committees of the American Farm Economic Association for the coming year:

H. Brooks James, North Carolina State College, Awards Committee.

Joe Mutti, University of Illinois, Student Section Committee.

E. C. Young, Purdue University, Investment Committee.

Frank Parsons, Federal Reserve Bank of Minneapolis, Special Committee to raise funds for the Awards Program

Harry Trelogan, Agricultural Research Administration, Washington, D.C., Special committee to review the Awards Program

E. T. Baughman, Federal Reserve Bank of Chicago, Special committee to review method of handling the reserves of the association

J. A. Ackerman, Farm Foundation, Chicago, Special committee to consider relationships between the association and the student section

The officers of the student section of the American Farm Economic Association for 1953-54 are:

President .....Chapman Dunham (Louisiana State University)
Vice President .....Don Thompson (Texas A & M)
Secretary-Treasurer .....David Aten (Pennsylvania State College)
Editor .....Andrew Hudson (Texas A & M)

William G. Adkins has been appointed Assistant Professor at Texas A. & M. College. He will conduct research in land economics.

Stephen A. Allen has joined the staff at the University of Kentucky as an

Assistant Economist to do research in production economics. Allen was formerly a graduate student at Kentucky.

Frank M. Atchley has joined the Grocery Manufacturers of America, Inc., as Agricultural Consultant. Previously he has been Director of Economic Research for the Illinois Agricultural Association in Chicago.

George H. Aull has been named a Fellow of the American Association for the Advancement of Science.

Gordon Ball has been appointed Assistant Professor at Iowa State College. He will teach and do research in farm management and production economics.

R. W. Bartlett, University of Illinois, has been granted leave for the month of September to work in California on problems related to milk marketing legislation in that state.

Russell Berry, Assistant Professor at South Dakota State College, will enter upon sabbatic leave October 1. He will spend the college year in graduate study at Harvard University.

Karl Brandt, of Stanford University, served during September and October as a research liaison agent for the Committee for Economic Development and an observer for the Ford Foundation in connection with the Comité Européen pour le Progrés Économique et Social and its four national chapters in Belgium, France, Germany and Italy. During three previous missions to Europe beginning in January 1952 he was, as a consultant to the Ford Foundation, instrumental in the formation and development of this independent organization of private business leaders in these four countries, whose objective is the economic integration of Europe.

Robert Brown, formerly of the Reclamation Service, has been appointed Assistant Professor at Chico State College, California. He has spent the past two years in graduate work in agriculture and land use at Harvard University.

Max E. Brunk of Cornell University is spending a six months' sabbatic leave working in the marketing facilities research branch of the Production and Marketing Administration.

Charles G. Carpenter, Division of Field Crop Statistics, Agricultural Estimates Branch, Bureau of Agricultural Economics, retired on August 31, after 36 years with the Bureau.

Russell L. Childress joined the Division of Agricultural Economics, U. S. Extension Service, the middle of July. Dr. Childress was with the Cornell Agricultural Experiment Station in 1948 and the University of Maryland from 1950 to 1952, doing research, extension and teaching in marketing fruits and vegetables.

W. E. Christian, Jr., is on leave from Mississippi State College and is Interim Associate Professor of Agricultural Economics at the University of Florida for the first semester 1953-54.

N. H. Comish, Professor of Business Administration, University of Oregon, retired July 1, 1953.

Clyas L. Crenshaw has resigned his position with the South Carolina Experiment Station to accept a position with the Florida Agricultural Statistician's Office in Orlando, Florida.

Robert L. Davis, Jr., is on leave, effective September 1, for graduate study at the University of Kentucky.

Ed Daniel, Field Agent in Farm Management at the University of Kentucky, will be on sabbatical leave the coming year to do graduate work at Harvard. Mr. Daniel is a recipient of a Littauer Fellowship.

LaVon S. Fife joined the Extension and Research staff of Purdue University as Assistant Professor, October 1, 1953. Just prior to that he completed work for the doctorate at Cornell University.

Lloyd Fisher, author of the recent book published by the Harvard University Press on *The Harvest Labor Market in California,* succumbed to Hodgkins disease at his home in Berkeley, California, in May 1953.

C. L. Folse has been promoted to Associate Professor at the University of Illinois.

Josiah C. Folsom, Division of Farm Population and Rural Life, Bureau of Agricultural Economics, retired on August 15, after 32 years with the Bureau.

M. Truman Fossum, Bureau of Agricultural Economics, received an award for outstanding research for 1952 from the Foundation for Floriculture of the Society of American Florists. The citation was given in recognition of 8 years of significant statistical research in floriculture, which culminated in the publication of "Trade in Horticultural Specialties," by the Bureau of Agricultural Economics.

Wade F. Gregory, Associate Agricultural Economist, employed jointly by Alabama Polytechnic Institute and B.A.E., is taking a year's leave of absence to do graduate work at the University of Chicago.

Carl R. Hall has been granted sabbatical leave from New Mexico State College for the college year 1953-54 to pursue graduate study toward the Ph.D. degree at the University of California and Oregon State College.

Miss Phoebe Harris of the Agricultural Extension Service of Arkansas has accepted a two-year assignment in charge of home economics extension work in Panama.

John W. Hicks is on part time leave of absence from Purdue University during the current academic year to serve as Research Director for the Indiana Tax Study Commission with headquarters at Indianapolis. This commission was created by the last General Assembly for the purpose of making an overall study of the tax structure in Indiana, and to make recommendations for changes to the next General Assembly.

T. A. Hieronymus has been promoted to Associate Professor at the University of Illinois.

John R. Hildebrand has been appointed Assistant Professor at Kansas State College during the leave of Fletcher Riggs. Mr. Hildebrand has been engaged in graduate study at the University of Chicago during the past two years.

Hans Hirsch has joined the research staff of the Bureau of Agricultural Economics. Mr. Hirsch was with the Office of Price Stabilization.

J. A. Hodges has been granted leave from Kansas State College for the fall semester to accept an appointment as a cooperative agent of the Foreign Agricultural Service. He will conduct a short course on Farm Planning and Work Simplification for a group of 38 agricultural leaders from countries of western Europe.

Roy E. Huffman has been promoted to Professor and Head of the Departments of Agricultural Economics and Rural Sociology and Economics and Sociology at Montana State College, effective September 16, 1953.

Edward B. Hogan, Research Assistant, University of Wisconsin, joined the staff of the University of Rhode Island, September 15, 1953. He will be in charge of the field work on a Consumer Preference Study on Frozen and Cut-up Chicken.

Verle R. Houghaboom, Assistant Agricultural Economist with the Extension Service at the University of Vermont, has returned from a two and a half month unsponsored tour of Norway, Denmark and the Netherlands. In these countries, he visited farms, farmers agricultural organizations and institutions.

Eldon C. Houghton, formerly Assistant Secretary of the Crop Reporting Board, Bureau of Agricultural Economics, has replaced Donald B. Pittman, transferred, in the Division of Field Crop Statistics of the Bureau.

Harold F. Huddelston transferred from the Bureau of the Census to the North Carolina Agricultural Estimates office of the Bureau of Agricultural Economics to work on a special cotton research program.

Conrado Hunter, at Harvard University during the past two years and at McGill University the year before, has been appointed Assistant Professor at the University of Puerto Rico.

Lewis P. Jenkins has returned to Mississippi State College after a year's leave of absence for graduate study at Iowa State College. He will continue his work in the field of Marketing and Cooperation.

Harald C. Jensen, formerly of Iowa State College, has joined the University of Kentucky as an Associate Professor and Associate Economist. He will concentrate his teaching and research in production economics.

Canute Johnson is employed as Assistant Professor and Assistant Economist at South Dakota State College.

W. Fred Johnson, at Harvard University in 1951-52, is in charge of the Point IV Program in Saudi Arabia.

Edwin B. Jones has accepted a position as Assistant Professor at Michigan State College, effective September 1. He received his Ph.D. at that institution in June 1953.

William O. Jones of Stanford University returned in September from a five months' tour of Western Europe, Central and West Africa, during which he undertook investigations of African agricultural systems. The immediate purpose of his trip was to collect additional firsthand information for his study of manioc.

C. R. Keaton, Associate Extension Economist at New Mexico, has been granted sabbatical leave for the college year 1953-54 to pursue graduate study toward the Ph.D. degree at the University of Minnesota.

Paul L. Kelley has returned to Kansas State College from sabbatical leave for graduate study at Iowa State College.

Bruce W. Kelly has been appointed Assistant Agricultural Economist in the Florida Agricultural Experiment Station and will be engaged in research in the field of citrus crop estimates.

M. M. Kelso became the new Dean of Agriculture and Director of the Agricultural Experiment Station at Montana State College on September 16, 1953.

Elmer Kiehl, who has been studying during the past year at Harvard University, resumed his work in livestock marketing at the University of Missouri, September 1. He has completed the residence requirements for the Ph.D. degree at Harvard.

Gordon Kleiman has been transferred from part time in dairy marketing extension at the University of Illinois to full time in distributor education with retailers of fruits and vegetables.

Lawrence W. Kreider completed his Ph.D. degree at Purdue University in August and accepted a position as Agricultural Economist with the Federal Reserve Bank of St. Louis.

Karl S. Landstrom has been appointed Chief, Branch of Research and Program Analysis, Division of Lands, Bureau of Land Management, with headquarters in Washington, D.C.

W. F. Lomasney joined the U. S. Extension Service in August as Extension Marketing Economist with responsibility for Extension's food merchandising program. Previously Mr. Lomasney worked in the state extension services of Rhode Island and Illinois.

Clifton W. Loomis, who completed his Ph.D. work at Cornell, has accepted an appointment at the University of Missouri as Assistant Professor in farm management.

Wilfred Malenbaum, formerly in the U. S. State Department concerned with investment in underdeveloped countries, is now concentrating on India under a grant to the Massachusetts Institute of Technology by the Ford Foundation.

Travis Manning is now Assistant Professor of Agricultural Economics at South Dakota State College. He formerly was a graduate student at Oklahoma A & M and the University of Minnesota.

Henry J. Meenan was appointed Acting Head of the Department of Rural Economics and Sociology at the University of Arkansas, effective July 1, 1953. He joined the University of Arkansas staff in September 1949.

James F. Miles has returned to Clemson College after attending the "Economics-in-action" program at Case Institute during the summer of 1953.

E. H. Moore, who recently completed his Ph.D. requirements at Michigan State College has joined the staff at the University of Maine as Assistant Professor and Assistant Agricultural Economist. He assumed his duties as of August 1.

Clyde E. Murphree resumed his duties on September 1 as Extension Economist with the Florida Agricultural Extension Service after a year of graduate study at Harvard University.

Joe R. Motheral, Associate Professor at Texas A. and M. College, has resigned to accept a position with the Division of Farm Population and Rural Life with headquarters in Washington, D.C.

John Nairn, Economist with the Canada Department of Agriculture at Vancouver, B.C., is taking a year's leave of absence beginning September 1 to work on his Master of Science Degree at Oregon State College.

Ottar Nervik, Associate Professor, South Dakota State College, visited his former home in Norway during the summer of 1953.

Richard Newberg has accepted a position as Assistant Professor and Assistant Economist at South Dakota State College. Mr. Newberg has been completing graduate work at the University of Minnesota.

William G. O'Regan has been appointed Interim Assistant Professor of Agricultural Economics and Agricultural Consultant to the Statistical Laboratory, University of Florida.

James L. Pearson has accepted a position as Assistant Economist at the University of Kentucky to do research primarily in livestock marketing. Pearson was formerly a graduate student at Kentucky.

Everett E. Peterson, who received his doctor's degree from the University of Chicago in 1952 and was formerly Assistant Professor of Agricultural Economics at Michigan State College, began his duties as Extension Economist in Farm Management with the Nebraska Agricultural Extension Service on September 1.

Gustof Peterson has joined the staff of the Division of Farm Management

and Costs, Bureau of Agricultural Economics, with field headquarters at Ames, Iowa. He received his doctor's degree at Iowa State College in July.

Weber H. Peterson, formerly at Clemson Agricultural College, and more recently Supervisory Economist and Chief of the Price Actions Branch of the Regional Office of Price Stabilization at Richmond, Virginia, has accepted a position as Assistant Manager of the Agricultural Department of the U. S. Chamber of Commerce in Washington, D.C.

Harold Phillips, formerly of the Bureau of the Census replaced Charles C. Carpenter, retired, in the Division of Field Crop Statistics, Bureau of Agricultural Economics.

Donald D. Pittman, formerly in the Division of Field Crop Statistics, Bureau of Agricultural Economics, has transferred to the State Statistician's office in Denver.

Clarence Prentice, Extension Economist at Michigan State College, has been granted a year's leave of absence to become Director, Michigan Office of the Production and Marketing Administration.

Marshall L. Remund resigned his position at South Dakota State College, effective July 1, 1953, and is now employed as an executive with Jensen Industries of Chicago.

R. R. Renne, President of Montana State College, returned to the College on August 1st to resume his duties following a two years' leave of absence during which he served as Chief of the Mutual Security Agency Mission to the Philippines.

Fletcher Riggs has been granted leave from Kansas State College during the 1953-54 academic year to accept a Social Science Fellowship at Vanderbilt University.

Paul R. Robbins is now on a joint research and extension appointment at Purdue University after completing the Ph.D. degree in August 1953.

R. Wayne Robinson, Assistant Agricultural Economist, Alabama Polytechnic Institute, has had his leave of absence extended to permit a continuation of graduate studies at the University of Wisconsin.

Robert O. Rogers has transferred from field headquarters in Stillwater, Oklahoma to the Washington office of the Division of Farm Management and Costs to work on a cooperative project with the Agricultural Research Administration. While in Oklahoma he worked on studies of irrigated farming in the W. C. Austin project area.

J. Z. Rowe, Extension Economist, returned to New Mexico State College in July after completing a year's graduate work toward the Ph.D. degree at Purdue University.

John D. Rowell has resigned from the University of Arizona to accept a position with the California Bureau of Markets.

F. M. Schrader, who has been Agricultural Economist with the Dominion Ministry of Agriculture, Ottawa, Canada, has accepted a position on the staff of Longstreet-Abbott, Inc., Commodity Counselors, St. Louis, Missouri.

Herbert Shepard, formerly of the Massachusetts Extension Service, has been appointed Assistant Economist for the Federal Milk Administration in the Boston Market.

Milton Shuffett, who has been a research intern with the Bureau of Agricultural Economics, has returned to the University of Kentucky where he will complete work for his Ph.D. degree.

Robert O. Sinclair has joined the University of Vermont staff as an Assistant

Agricultural Economist. He will be working on a bulk tank, milk pick-up study and teaching Farm Credit.

R. L. Skrabanek, Assistant Professor, was named "Outstanding Professor in the School of Agriculture" at Texas A. and M. College for the school year 1952-53.

William P. Stephens of New Mexico State College has been promoted to Assistant Agricultural Economist.

Christian A. Stokstad has transferred from the Division of Farm Management and Costs, Bureau of Agricultural Economics, to the Agricultural Estimates Branch of the Bureau. He will work in the Washington State office.

John Tabb, who has been serving as Assistant Professor at South Dakota State College, is now studying at Cornell University.

Marlowe M. Taylor, formerly with the Bureau of Reclamation at Minot, North Dakota, has joined the staff of the Mortgage Section, Division of Agricultural Finance, Bureau of Agricultural Economics.

D. Woods Thomas will join the Teaching and Research staff of Purdue University as Assistant Professor of Agricultural Economics, January 1, 1954. He plans to complete the doctorate at Pennsylvania State College in January 1954.

James F. Thompson, Assistant Economist at the University of Kentucky, will be on leave of absence the coming year to do graduate work at the University of Chicago. Mr. Thompson received a General Education Board grant.

Tyrus R. Timm has assumed his duties as the new Head of Department of Agricultural Economics and Sociology at Texas A. and M. College. He was formerly Extension Agricultural Economist at the same institution and succeeds Mr. L. P. Gabbard, who will remain with the Department on partial retirement.

John T. Timmons of Iowa State College was a member of the United Nations Staff at the Latin American Land Problems Seminar held at Campinas, Brazil during May and June of this year.

Alvin S. Tostlebe, for the last 3 years on leave from the College of Wooster, Wooster, Ohio, as Head of the Mortgage Section of the Division of Agricultural Finance, Bureau of Agricultural Economics, has resumed his college duties as Head of the Department of Economics. During his Washington stay he worked on a cooperative study by the Bureau of Agricultural Economics and the National Bureau of Economic Research on capital requirements in agriculture.

Thomas E. Tramel has returned to Mississippi State College after a year's leave of absence for graduate study at Iowa State College. He will continue his work in the field of Farm Management.

Lawrence W. Van Meir has been appointed Assistant Professor at Kansas State College to direct research and teaching in livestock marketing.

Raymond E. Vickery has transferred from the Production and Marketing Administration to the Mississippi office of Agricultural Estimates, Bureau of Agricultural Economics, to work on a special cotton research program.

The University of Wisconsin and the Central University of Venezuela have signed a ten-year "intellectual collaboration" agreement, providing for the loan and assignment of staff members to the latter institution. Early emphasis is being given to the Social Sciences, Agricultural Services, Education and Medicine. George W. Hill is coordinator of the program. The program is unique in that no government agencies or foundations other than the two collaborating institutions are involved.

S. W. Warren of Cornell University spent six weeks in Brazil this summer studying the agriculture of the country, reviewing the work of the Department of Rural Economics of the Universidade Rural in Viscosa, Minas Gerais, and making suggestions for the further development of that Department. Professor Warren also gave a course in research methods in farm management during his visit.

Walter O. Wagner, who completed his doctorate at Purdue University in August 1953, has accepted a position as Economist with the Commodity Appraisal Service at Chicago, Illinois.

W. J. Wills, formerly at the University of Illinois, has accepted the position of Director of Agricultural Relations, American Trucking Association, Washington, D.C.

Ramon Wilson, who completed his doctorate at Purdue University in 1950, has resigned his position as Extension Specialist at Utah State College to accept a position with the California Department of Markets at Sacramento, California.

G. B. Wood, Head of the Department at Oregon State College, was selected Chairman of the Board of Trustees of the American Institute of Cooperation at the annual meeting held at Columbia, Missouri in August. He succeeded Asher Hobson, formerly of the University of Wisconsin, who had held the chairmanship for a number of years.

HARRY C. WOODWORTH

A life devoted to the service and welfare of rural people ended with the death of Harry Woodworth, on Friday, September 18, 1953. It was typical of his sense of duty towards his associates in the department of which he was chairman for fifteen years and towards the farmers of the state in which he worked, that it was at a county meeting of farmers at Milan, New Hampshire, where he was taken ill, never to recover.

Farm management was, with him, both a profession and a hobby. His publications were written with an earthy tang that can only be derived from a love of the soil, and they stand as memorials both to his modesty and to his concern for better farming. His fund of experiences and his perspective will be sadly missed as an inspiration for research and as a moderating influence on every day discussions. Much of his record is living rather than written.

His spare time was given to a farm in Minnesota acquired after graduation from the University of Illinois in 1909. At first, abandoned and run down, its present healthy and productive condition is sufficient evidence of results from the farm planning and land use practices about which he taught. Part of Harry is in that farm and it is perhaps fitting that his body should travel back from New England to Minnesota for its final resting place.

New England has lost a good man whose unassuming and self-effacing character belie the influence which he had and which he leaves behind.

J.R.B.

PROFESSOR A. W. ASHBY, C.B.E.

The death of Professor Ashby which took place suddenly on September ninth, in his sixty-seventh year, will leave a large gap in the ranks of those who

have pioneered in the science of Agricultural Economics.

His achievement and influence cannot be truly represented in a statement of this nature, but it may give something of the man when we recall that his brilliant academic career started in a British elementary school in Warwickshire, and finished as Director of Agricultural Economics in the University of Oxford. As a young man he won scholarships which took him to Ruskin College, Oxford. Later he was awarded the first scholarship given by the Ministry of Agriculture which enabled him to study at the University of Wisconsin where he had contacts with such men as Ely and Taylor.

He was an economist with very wide interests, both national and international. To him the subject embraced a great deal more than the "economic," in its narrow sense. It was apparent that the human factor was uppermost in his mind, holding his main interests, and obviously, provided his ultimate standard. He was thorough in his analysis and constantly debunked wishful thinking.

The British farmer and farm worker too, owe a great deal to his continuous interest in the welfare of British agriculture. His long service as member of the Agricultural Wages Board is but one example of the high place he held in the opinion of those responsible for the industry's progress.

His deep knowledge of the agricultural industry, coupled with his technical aptitudes, singled him out to be a member of many committees and commissions. He was a prominent member of the 1920 Royal Commission and later the "Linlithgow" Committee, the deliberations of which have had such a profound influence on British agricultural policy since 1924. Again his work on milk marketing, and as a member of the committee, helped lay the foundation of the Milk Marketing Boards in Britain.

He was as keen to know about the conditions under which the people of the countryside lived as he was, for example, to find out all about the latest piece of agricultural machinery. In this he was at home, so to speak, whether walking over a farm applying his critical eye, or on the rostrum debating the intricacies of international trade or currency problems.

He was a successful teacher and many people, now holding important appointments in agriculture in various parts of the world passed through his hands at Aberystwyth, where he spent twenty-two years as the head of the Department of Agricultural Economics, or at Oxford, where he was Director for seven years.

Last year he was given the signal honor of being appointed, for the second time, as President of the British Agricultural Economics Society. He had also served as one of the Vice-Presidents of the International Conference of Agricultural Economists.

He was a prolific writer on economic topics and the essential aspects of agrarian problems. His writings are scattered through many publications and their variety reflect his many interests.

Those of us who were privileged to know and work with Professor Ashby on conference activities will miss him very deeply, but the whole world of agricultural economics, too, is much the poorer by his passing.

J.R.C.
K.T.W.

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